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ICOM Committee for Conservation

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ICOM Committee for Conservation

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ICOM Committee for Conservation

Comité pour la conservation de l'ICOM

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VI

Composition and working rules for the ICOM Committee for Conservation

1. The Committee and its aims

1.1 *The ICOM Committee for Conservation* is a permanent committee of the International Council of Museums.

Among its aims are ·

a. The achievement and maintenance of the highest standards of conservation and examination of historic works by bringing together from all countries those who are responsable for cultural property: restorers, research workers and curators.

b. to promote researches of a scientific or technological nature pertaining thereto.

c. to collect data and information about materials and workshop methods.

d. to make generally available by publication or otherwise the esults of such enquiries.

1.2 *The ICOM Committee for Conservation* is composed of the *Directory Board* and *Working Groups* with their *Coordinators*. The members of the Directory Board and the Coordinators must be members of ICOM or must undertake to become members within three months of appointment; membership is not considered to be an essential requirement in other cases.

2. Directory Board

2.1 The Directory Board (hereinafter called the Board) is composed of eight members elected for three years by the Committee and one ex-officio member, namely the Director of the Rome Centre. Members are eligible for reelection.

2.2 The board elects its Chairman from among the elected members and appoints an Administrative Secretary and a Secretary for Publications.

2.3 Among the elected members of the Board, who may also be Coordinators, should be represented Museum Curators, Restorers and Museum Scientists.

2.4 Delegates from international organizations such as UNESCO, IIC, and ICOMOS will normally be invited to attend meetings of the Board as observers.

2.5 The Board will endeavour to meet at least once every year.

2.6 The functions of the Board are the following :

a. to appoint Coordinators for definite tasks and for fixed periods of time.

b. to establish with Coordinators the programme of the Committee for Conservation.

c. to control the progress of work.

3. Coordinators

3.1 Coordinators will hold their offices at the discretion of the Board.

3.2 The Coordinator will choose the members of his Working Group in consultation with and with the approval of the Board and will direct its activities.

3.3 With the approval of the Board the Coordinator may organize joint meetings of specialists in his field, visits to laboratories, sites, etc., having a direct bearing on the progress of his investigation.

3.4 Each Coordinator will submit, annually, to the Secretariat of the Committee for Conservation and not later than 3 weeks before the meeting of the Board, a report on the progress of the work of his group.

4. Working Group Members

4.1 On a proposal from the Coordinator, and with the approval of the Board, members will be assimilated in a group and be allocated a particular subject to study.

5. Procedure and Finance

5.1 The Committee for Conservation meets normally every 3 years in full session to hear reports on the progress of the work being carried out by the working groups under their Coordinator, to propose future programmes to the Board, and to encourage contact between the members of the working groups.
All interested persons may attend meetings with the approval of the Chairman of the Board.

5.2 While Groups meet by arrangement at times found to be most expedient, the Board will endeavour to meet annually.

5.3 Manuscripts prepared by Working Groups which are ready for publication shall be passed to the Secretary for Publications for submission to the International Coordination Committee for Publications.

5.4 The Committee's budget will be submitted for approval every 3 years to the full session of the Committee.

6. Amendments

The Directory Board will have the power to make provisional changes in the composition and working rules to be presented for ratification at the next meeting of the Committee.

VIII

Statuts du Comité de l'ICOM pour la Conservation

1. Le comité et ses buts

1.1 *Le Comité de l'ICOM pour la Conservation* est un comité permanent du Conseil International des Musées.
Ses buts sont entre autres :

a. d'atteindre et de maintenir le plus haut niveau de la conservation et de l'examen des oeuvres d'art en mettant en contact ceux qui - dans tous les pays - sont responsables pour les biens culturels : restaurateurs, chercheurs scientifiques et conservateurs.

b. de promouvoir des études scientifiques ou technologiques rélatives à cet objectif.

c. de réunir des données et des information sur les matériaux et les méthodes d'atelier.

d. de diffuser les résultats de telles enquêtes par des publications ou autrement.

1.2 *Le Comité de l'ICOM pour la Conservation* est composé d'un *Conseil de Direction* et de *Groupes de Travail* avec leurs *Coordinateurs*.
Les membres du Conseil de Direction et les Coordinateurs doivent etre members de l'ICOM ou le devenir dans les trois mois après leur nomination. Dans les autres cas il n'est pas consideré essentiel d'être membre de l'ICOM.

2. Le Conseil de Direction

2.1 Le Conseil de Direction (nomme le Conseil ci-dessous) est composé de huit membres élus pour trois ans par le Comité et du Directeur du Centre de Rome, qui en fait partie ex officio. Les membres peuvent etre réelus.

2.2 Le Conseil choisit son Président parmi les membres élus et nomme un Secrétaire Administratif et un Secrétaire aux Publications.

2.3 Parmi les membres élus du Conseil, qui peuvent être également des Coordinateurs, les conservateurs de musée, les restaurateurs et les spécialistes de laboratoire de musée doivent être représentés.

2.4 Des représentants des organisations internationales comme l'UNESCO, l'IIC et l'ICOMOS seront généralement invités à assister aux réunions du conseil à titre d'observateur.

2.5 Le Conseil essayera de se réunir au moins une fois par an.

2.6 Les fonctions du Conseil sont les suivantes :

a. de nommer les coordinateurs pour des tâches bien déterminées et pour des périodes fixées.

b. d'établir le programme du Comité pour la Conservation en accord avec les Coordinateurs.

c. de contrôler le progrès des travaux.

3. Coordinateurs

3.1 Les Coordinateurs garderont leurs fonctions sous l'approbation du Conseil.

3.2 Le Coordinateur choisit les membres de son Groupe de Travail en consultation et avec l'approbation du Conseil et en dirige les activités.

3.3 Le Coordinateur peut organiser avec l'agrément du Conseil des réunions de specialistes dans la matière de son ressort, des visites aux laboratoires, sites, etc. directement liées au progrès de son travail.

3.4 Chaque année et trois semaines avant la réunion du Conseil au plus tard le Coordinateur envoie au Secrétariat du Comité pour la Conservation un rapport sur l'état d'avancement du travail de son groupe.

4. Les membres des Groupes de Travail

4.1 Sur la proposition du Coordinateur et avec l'approbation du Conseil, des membres seront assimilés dans un groupe pour l'étude d'un sujet déterminé.

5. Fonctionnement et Finances

5.1 Le Comité pour la Conservation se réunit normalement tous les trois ans en séance plénière pour entendre les rapports sur le progrès du travail exécuté par les Groupes de Travail sous la direction du Coordinateur, afin de proposer les programme futurs au Conseil et pour encourager les contacts entre les membres des Groupes de Travail.
Toutes les personnes intéressées peuvent assister aux réunions du Comité avec la permission du Président du Conseil.

5.2 Les Groupes de Travail arrangent des réunions aux moments les plus propices; le Conseil tâchera de se réunir chaque année.

5.3 Les manuscrits préparés par les Groupes de Travail destinés à être publiés seront envoyés au Secrétaire aux Publications afin d'être soumis au Comité International de Coordination pour les Publications.

5.4 Tous les trois ans le budget du Comité est soumis à l'approbation du Comité en séance plenière.

6. Amendements

Le Conseil peut faire des changements provisoires dans les Statuts à presenter pour une ratification à la prochaine réunion du comité.

ICOM Committee for Conservation

Comité pour la conservation de l'ICOM

Participants in the meetings of the ICOM Committee for Conservation are personally invited not as representatives of their country or Institution but as specialists in their field.

Les participants aux réunions du Comité pour la conservation de l'ICOM sont invités personnellement à titre de spécialiste; ils ne représentent ni leur pays ni leur institution.

ICOM Committee for Conservation

4th Triennial Meeting, Venice 1975

By-laws for the Elections of the Directory Board

1. The election of the Directory Board by the Committee takes place every three years during the Plenary Meeting of the Committee.
2. The Directory Board is elected by those present at the Plenary Meeting who have been members of the Committee in the three preceding years.
3. All electors are eligible.
4. Members can put themselves up for election by informing the Secretariat either orally or in writing of their candidacy not later than 24 hours before the election. No candidates can be accepted after this dead-line. Candidates should mention to the Secretariat whether they consider themselves a curator, restorer or scientist.
5. It is not necessary for a candidate to support his candidacy with signatures of members. A provisional list of candidates containing at least sixteen names in alphabetical order is prepared by the Directory Board.
6. The Secretariat prepares a voting-ballot by arranging the candidates in three columns according to their belonging to one of the three categories: curators, restorers or scientists. Each candidate can only appear in one column. Initials and full name of the candidate should be mentioned on the voting-ballot.
7. Prior to the election the Secretariat shall distribute one voting-ballot only to each individual member. The Secretariat shall keep a record of this distribution.
8. Prior to the election a Supervisor of the election is appointed from among the members present as well as two Overseers. The Supervisor opens the voting-boxes and reads the results. These are recorded by two persons appointed by the Secretariat. The Overseers check that the votes are correctly recorded.
9. Each member shall name a maximum of eight candidates on the voting-ballot by placing a cross behind their names. Each column, corresponding with a category of curators, restorers or scientists should contain at least two crosses.
   Voting-ballots containing more than eight crosses are void.

10. Members shall put their individual voting-ballot into a previously sealed voting-box. Voting-ballots should be signed by the Supervisor before being put into the voting-box.

    Voting-ballots not carrying the signature or initials of the Supervisor are void.

11. When the time allotted for the voting is expired the voting-boxes shall be assembled and opened by the Supervisor whereupon the public counting of the votes shall proceed.

12. The number of crosses appearing after the names of a candidate is recorded. When all voting-ballots have thus been counted the numbers are added-up.

13. Are being elected first the two candidates who in each column have acquired the greatest number of votes. When two candidates in one category have obtained an equal number of votes and this number is greater than that of any other candidate in that category, they shall both be elected. When three or more candidates in one category have the same number of votes and this number is greater than that of any other candidate in that category two of them shall be assigned by lot. When two or more candidates in one category have acquired an equal number of votes and this number is smaller than that obtained by one other candidate in that category but greater than that acquired by any other candidate in that category one of these candidates shall be assigned by lot.

14. When thus the first six members of the Directory Board have been elected two further members shall be elected from among the remaining candidates i.e. the two remaining candidates from any category having acquired the greatest number of votes. When two of the remaining candidates have obtained the same number of votes greater than that of any other remaining candidate they shall both be elected. When three or more of the remaining candidates have obtained the same number of votes and this number is greater than that of the other remaining candidates two of them shall be assigned by lot. When the above situations do not occur and two or more remaining candidates have acquired the same number of votes and this number is smaller than that obtained by one other remaining candidate but greater than that obtained by all other remaining candidates, one of them shall be assigned by lot.

Assigning by lot is carried out by the Supervisor according to a procedure of his choice. When more than two candidates from the same country are elected only the two candidates having acquired the greatest number of votes or being assigned by the above described procedure are confirmed. The vacancy thus created shall be filled by applying the procedure described in articles 13 and 14.

15. The newly elected Directory Board assumes its functions from the moment that the results are read to the Plenary Meeting by the Supervisor or the Secretariat.

16. The Supervisor shall decide in matters arising during the electorial procedure for which these By-Laws do not provide.

XIV

Comité pour la conservation de l'ICOM

4ème Réunion triennale, Venise 1975

Projet de loi pour les élections du Comité directeur

1. L'élection du Bureau directeur par le Comité prend place chaque trois ans durant la Réunion plénière du Comité.

2. Le Bureau directeur est élu par ceux présents à la Réunion plénière qui ont été membres du Comité durant les trois précédentes années.

3. Tous les électeurs sont éligibles.

4. Les membres peuvent se présenter eux-mêmes aux élections en informant le Secrétariat, soit oralement soit par écrit, de leur candidature pas plus tard que 24 h avant l'élection. Aucun candidat ne peut être accepté après cette date limite. Les candidats mentionneront au Secrétariat qu'ils sont curateur, restaurateur ou scientifique.

5. Il n'est pas nécessaire pour un candidat de faire appuyer sa candidature par des signatures de membres. Une liste provisoire des candidats comprenant au moins seize noms dans l'ordre alphabétique est préparée par le Comité directeur.

6. Le Secrétariat prépare les bulletins de vote en répartissant les candidats en trois colonnes suivant qu'ils appartiennent à l'une des trois catégories: curateur, restaurateur ou scientifique. Chaque candidat ne peut apparaître que dans une seule colonne. Les initiales et le nom entier du candidat seront mentionnés sur le bulletin de vote.

7. Avant l'élection le Secrétariat distribuera un bulletin de vote à chaque membre individuel. Le Secrétariat teindra un registre de cette distribution.

8. Avant l'élection un Président de l'élection est nommé par les membres présents ainsi que deux Assistants. Le Président ouvre les urnes et lit les résultats. Ils sont enregistrés par deux personnes nommées par le Secrétariat. Les Assistants controlent que les votes sont correctement enregistrés.

9. Chaque membre pourra nommer au maximum huit candidats sur le bulletin de vote en plaçant une crois derrière leurs noms. Chaque colonne correspondant à une catégorie de curateurs, restaurateurs ou scientifiques contiendra pour le moins deux croix. Les bulletins contenant plus de huit croix sont nuls.

10.Les membres devront mettre leur bulletin de vote individuel dans une urne scellée auparavent. Les bulletins de vote seront signés par le Président avant d'être mis dans l'urne.

Les bulletins de vote ne portant pas la signature ou les initiales du Président sont nuls.

1. Le temps alloué au vote terminé les urnes seront rassemblées et ouvertes par le Président; là-dessus les votes seront comptés en public.

2. Le nombre des croix apparaissant après les noms d'un candidat est enregistré. Quand tous les bulletins de vote ont été comptés, les nombres sont additionnés.

3. Sont élus en premier les deux candidats qui, dans chaque colonne, ont acquis le plus grand nombre de votes. Quand deux candidats d'une même catégorie ont obtenu un nombre égal de votes et ce nombre est plus grand que celui de quelque autre candidat dans cette catégorie, ils seront considérés comme élus ensemble. Quand trois candidats ou plus dans une même catégorie ont le même nombre de votes et que ce nombre est plus grand que celui de quelque autre candidat dans cette catégorie, deux d'entre eux seront tirés au sort. Quand deux ou plusieurs candidats dans une même catégorie ont acquis un nombre égal de votes et que ce nombre est plus petit que celui obtenu par un autre candidat dans cette catégorie, mais plus grand que celui acquis par un autre candidat dans cette catégorie, un de ces candidats sera tiré au sort.

4. Ainsi quand les six premiers membres du Comité directeur ont été élus deux autres membres seront élus parmi les candidats restants, c.à.d. les deux candidats restants de quelque catégorie ayant acquis le plus grand nombre de votes. Quand deux des candidats restants ont obtenu le même nombre de votes plus grand que celui d'un autre candidat restant, ils seront élus. Quand trois ou plus des candidats restants ont obtenu le même nombre de votes et que ce nombre est plus grand que celui des autres candidats restants, deux d'entre eux seront tirés au sort. Quand les deux situations mentionnées ci-dessus ne se produisent pas et deux ou plus des candidats restants ont obtenu le même nombre de votes et que ce nombre est plus petit que celui obtenu par un autre candidat restant mais plus grand que celui obtenu par tous les autres candidats restants, un d'entre eux sera tiré au sort. Le tirage au sort est mis à exécution par le Président suivant une procédure de son choix. Si plus de deux candidats sont élus d'un seul pays, seuls les deux candidats ayant obtenu le plus grand nombre de

votes ou étant assignés par la procédure décrite ci-dessus seront confirmés. Le vide créé ainsi sera rempli par l'application des articles 13 et 14.

15. Les nouveaux élus du Comité directeur assument leurs fonctions à partir du moment où les resultats sont lus à la Réunion plénière par le Président ou le Secrétariat.

16. Le Président décidera en la matière survenant durant la procédure électorale pour laquelle ces lois n'auraient rien prévu.

THE CEMETERY CHAPEL OF STA. MARIA, PONTRESINA

Oskar Emmenegger

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The chapel is situated close to St. Moritz in Oberengadin, in the county of Graubünden. The important east-west and north-south Alpine passes have since classical times played a very important role for this high valley. These old trading routes also gave Engadin a strategic importance. Here, in accordance with the good trading position, are to be found a great number of works of art of the highest quality. Typical for this area, as for the whole of Graubünden, is the fact that one finds works by artists whose homes were situated either south or north of the Alps, depending on the political situation at the time. This position, easily accesible from the south, resulted throughout the centuries in a leaning towards the art of northern Italy.

It is not surprising then that Byzantine paintings from the end of the twelfth century are to be found in the chapel in Pontresina. Likewise the wall-paintings dated 1495 can be attributed to an Italian master.

The first documentary mention of Pontresina was in 1139 as "ad pontem sarissinam". This nomenclature shows the handed-down reports of the Saracen invasion of 936 to be correct. The chapel itself is first mentioned on the 20th April, 1450 and was under the patronage of St. Mary. The Byzantine wall-paintings and parts of the structure itself are proof of a building much older than that mentioned documentary. A closer look at the tower and the louvre-windows with their tooth-shaped surrounds and the simple block-shaped capitals, shows that it can be attributed to the late twelfth century.

The examination of the building and foundations during the restoration resulted in the following plan:

The tower was built onto the outside of the south-wall of the original main-nave. The west-wall was found to be the oldest part of the church. In a corner by the southern connecting wall, remains of the foundations were found, and their direction could be traced for about a metre. Comparisons between the type of stonework in the tower and of the west-wall, with that of the rest of the building showed distinct differences. For this reason it can be concluded that the apse, north and south-walls are younger than the remaining west-wall. It is interesting to note that on the outside of the west-wall two oculi, one above the other, are visible. The lower of the two is situated on the same level as the Byzantine wall-paintings, thus proving that the lower part of the west-wall is older than the twelfth century paintings. This observation is further supported by the fact that the "intonaco" was applied on top of an older lime-washed plaster, on which the yellow sinopia of the Byzantine painting can also be detected.

In 1450, the north, east and south-walls of the building were demolished. A part of the north-wall and the west-wall were joined onto the new building.

In 1477, the surrounding walls of the present building were erected. This date stands above the door at the entrance to the cemetery.

In 1495, the inside of the church was completely painted, including a part on the outside of the south-wall and the re-plastered Byzantine paintings.

In 1497, the primitive ornamental painting of the wooden ceiling took place and the date can still be seen today.

In 1535, the whole of the paintings were lime-washed, as a result of the Reformation.

In 1860, parts of the walls in the nave and apse were knocked out and windows put in.

In 1913, Christian Schmid discovered the paintings, dated 1495 and uncovered an area of them.

In 1934, a Belgian, Lefebure, found and uncovered further areas of the paintings and at the same time, discovered the Byzantine paintings.

In 1962, the present restoration began and further areas of the Renaissance wall-paintings have been discovered.

The iconographical study of the chapel

The wall-paintings outside. Above the entrance sits the Virgin Mary on a throne with her Child resting. To the left stands St. Peter with his attribute, a key; to the right a bishop who is not identifiable.

Above, in a separate picture, the legend of St. George, one of the most frequently represented figures in the area, can be seen. The moment in which the Saint drives his spean into the throat of the dragon is represented.

The paintings inside. The paintings inside the church follow a scheme which can be traced back to late-classical times. The spherical ceiling of the apse is dominated by Christ in the mandorla, surrounded by the symbols of the Evangelists and the four western church Fathers. Along the wall of the apse, stand the twelve Disciples and in a border along its front edge the busts of the old-testament Prophets are pictured.

Both of the two representations of Mary, one at each side of the apse on the triumphal arch, were originally crowned with plastered canopies and hence as altarpaintings intended.

Above is the representation of the Annunciation. The representation of God the Father is iconographically interesting; as he lets Christ with the cross on his shoulder slide from his arms. The dove of the Holy Ghost can be seen beneath. Immediately alongside on the choir-arch are scenes showing the Passion of Christ; God the Father with Christ on the cross, St. Bebastian and the Archangel Michael. In the south-west corner beside the Annunciation begin the scenes from the life of Christ. This cycle continues around the inside of the church. Each painting is separated from the next by painted columns, except those on the north-wall.

On the west-wall stands a complete cycle of the story of Mary Magdalene. The adjoining painting shows the raising of Lazarus, confirming the fact that, as in the middle-ages, Mary, the sister of Lazarus, was often mistaken for Mary Magdalene.

Underneath the pictures from the life of Christ, a large figure group of the Last Judgement covers the rest of the south-wall.

On the west-wall, beneath the paint layer from 1495, are the remains of the Byzantine paintings. Represented here, within a painted architectural-arch, beneath a perspective meander in which animals are painted, are three scenes from the life of Christ: the Offering of the three Kings; the Christening in the Jordan, and the Last Supper with the Washing of the feet.

Only a few fragments from the painted band beneath remain, such as the head of a soldier with his weapons.

Damage and its causes

In 1913, the first uncovering of the paintings took place, unfortunately in a rather unhelpful manner. This removal with hammer and spatula resulted in severe damage to the paint surface; the paintings were scratched and hacked. The extent of loss depended on the degree of carbonisation of the plaster with the pigments. As a result of capillary and reflected dampness in areas around ground-level, the plaster and paint-layers are strongly bound and carbonised throughout. The extent of loss during the removal of plaster is in these areas less. The plaster in the higher parts of the painting is softer and for this reason, the removal of overplaster with a hammer in 1913 resulted in loss of areas of plaster together with painting. The average loss amounted to about 35 %. Approximately 30 % of the limewashed overpainting were not removed and the whole, more or less in the sense of the sconcely visible original was overpainted. In accordance with earlier beliefs the large areas of loss were indistinctly retouched and finally the whole was fixed with concentrated water-glass.

In 1934 Lefebure uncovered the Magdalene pictures with a spatula and a knife; these have also a very badly scratched surface. As mentioned earlier, Lefebure discovered the Byzantine paintings. He sacrified, without thinking, large areas of the Magdalene cycle, in order to be able to uncover the older paintings underneath. The "intonaco" of the Renaissance paint-layer is very hard and strongly bound with the twelfth-century paintings. During removal of areas of the Renaissance paintings, parts of the older painting were unfortunately also ripped from the wall. The complete loss of areas of the fifteenth century painting along with up to 50 % of the paintings from the twelfth century is unanswerably large. Lefebure also left behind approximately 30 % remains of lime and plaster on the paintings. In order to allow the colours to appear intenser, Lefebure fixed the paintings with gum arabic, and thus the lime-smears seem optically to disapear. The high hygroscopic properties of the gum arabic resulted in stretching on the paint surface. In summer, the gum arabic takes in the damp and in the dry winter time releases it again. As a result of the material being forced to swell and shrink through the changing water content, the Byzantine paintings unrolled partly. Proper conservation measures, except for the covering of the roof with shingles, in 1913 and 1934 were not

carried out. As I began the restoration in 1962, I found everything in terrible condition. Avalanches and above all a landslide in the seventeenth century have altered the ground-level outside the church towards the side of the mountain (north), by more than 2 metres. The dampearth lay for hundreds of years against the outside wall. The huge amount of dampness could only vapourise through the inside of the north-wall, which was painted. Along with the dampness, considerable quantities of sodium sulphate and nitrate were carried through to the surface, where the salts then pressed against the paintings. One could follow the level of the ground outside, which sloped from north to west, inside along the apse, and thus recognise the cause of the damage. The pressure from the mountain increased the rising-effect of the capillary-dampness. The foundations on the south-side are not deep. Pontresina lies over 1800 m above sea-level. At this hight, the freezing-point, even during a mild winter, lies deep under the foundations of the south-wall. The results are as follows: the water freezes and expands. Cracks were the result on the weaker areas of the south-wall. Further damage arose from defective areas in the roof.

Pontresina is a very popular tourist attraction. The carving of names or the leaving behind souvenirs is the unjust result of thoughtless passing visitors.

The damage due to dampness on the inside walls was terrible and an effect of the visitors. In the eighteenth century, wooden wall-panels were erected around the inside-walls according to the height of the damage. Plug-holes had to be knocked into the walls in order to secure these panels, naturally causing damage to the paintings. The building of a balcony and the positioning of the pulpit also produced irrevocable loss of wall-painting. These are just a few of the many causes of damage either through improper restoration or effects of the weather, which have to be corrected.

Restauration

The aim of the restoration from the beginning was as follows:

1) The clairification of the causes of damage.
2) Conservation of the areas of painting from 1495 in most danger.
3) Complete uncovering of the paintings above the entrance and on the tower.
4) Clairification, whether the Renaissance paint-layer could be removed without damaging the Byzantine painting, which must remain on the wall.

Natural effects, hard weather-conditions and incorrect restoration methods are the factors, which make the latest restoration immediately necessary.

Before the work could be started, a number of repairs had to be carried out. Around the outside of the church-walls, a ventilation-shaft was dug and covered over with paving-stones. This was to carry rain-water as quickly as possible away from the wall and at the same time, through air-circulation, keep the wall dry. A horizontal insulation ensured that the capillary-dampness was stopped. Tarred roofing-sheet and lead-foil were pushed into openings made in the stonework; these openings were later cemented over. The quarry-stone here is granite, which meant that a cut could not be made by boring. In addition, the painted inside plaster in the lower areas was loose and through strong vibration would have fallen away. On the inside wall of the apse, a specimen section of about 1 sq. metre was plastered to see how it would hold. After just a year, the plaster surface was covered in mould. After a further year, the surface had peeled off, whereas the areas below remained in good condition. This showed that water from above was seeping through the wall. The measures carried out were not enough.

The rain-water flowed behind the pavel-covering into the wall, above the horizontal insulation. This fault could be corrected with a copper-seal, which was attached, approximately 20 cm above outside-ground-level, to the vertical stonework and continued down beneath the paved-cover into the shaft, where it ended like a gutter (see diagram).

This seal was plastered to the stonework where visible. The amount of reflected water at the wall could be reduced to a minimum by laying grass-sods. These measures have proved themselves. Even today, after a period of ten years, no damage can be detected. Further measures were necessary, such as the felling of trees which came up against the wall. The water-spouts on the roof were extended, as the wind kept blowing rain-water onto the walls. The roof was renewed. The wood-panels against the inside lower parts of the walls were rotten due to the damp, and therefore removed. The mortar behind these panels was completely destroyed through sodium sulphate, nitrate and fungus, and also had to be removed. At this time I discovered the lower areas of the Last Judgement, which was covered with five layers of lime-wash.

The uncovering of these newly discovered paintings from 1495 had then to be carried out. Specimen cleanings showed the painting, including the finest details, to be very well preserved. Their uncovering was forced to begin because the "intonaco" around ground-level hung loose with a gap of up to 4 cm from the wall. During the removal of the lime, one was able to see where holes could be made for the necessary injections. In spite of the problems, the paintings were cleaned over a long period of time.

The three topmost lime-washes could be removed with a scalpel. The layers beneath were sintered like glass and could only be removed using small sanding-discs on rotating spindles. The thinner the layer, the smaller the sanding-head which had to be used. The last thin film was removed using an Airbrasive-machine. The uncovering of areas of terra-verte and azurite gave the most problems. The darker iron-oxide pigments (haematite) were loosely bound and easily wiped off, and were thus fixed with 3% paraloid B 72. Only after the cleaning could one see the difference in results between the uncovering in 1913 and 1934 and that by the present restoration. This is most important when one considers how complete the painting of the chapel could have been. Areas of loss were used as openings for injections. Different mixtures of fine and coase sand; pit-lime and a little cement were used depending on the size of the gap to be filled. The injected areas could be pressed back against the wall by applying slight pressure for a period of about four days. The results of the cleaning were so satisfactory that it was decided to re-restore the whole of the chapel. As described above, the remainder of the lime-washes was removed and overpaintings were easily cleaned away using the Airbrasive machine, thus bringing to light the original and the areas of loss. The trattegio method of retouching showed here to be the most satisfactory. The glazes from 1913 on top of areas of loss were often kept as underpainting for these retouchings. The latter were applied lighter in tone in order to show clearly and unite the fragments of original. The coherence of the paintings without retouching would have not been apparent.

Transfer of the Renaissance paintings

As already mentioned, two paint-layers dating from the twelfth and fifteenth centuries cover the west-wall. The "intonaco" of the topmost paint-layer is between 3 and 7 mm thick. The first-class work of the craftsmen in applying the plaster increased the difficulty in separating the two layers which were very well bound. The

difference in toughness of the two layers; the twelfth century one being much softer and sandier, also increased the difficulties. In addition, there was no dirt-layer on top of the older painting which would have eased the task. Transfer-specimens using the "strappo" method, gave undesirable results; up to 90 % of the twelfth century painting remained stuck to the back of the topmost layer. It could also not be sufficiently checked to see whether, through surface tensions, the Renaissance paint-layer had become loose from its ground. The paint-layer alone could not be transferred using the strappo method, as either none or both of the two layers came away from the wall. It took three summers before a suitable method of transfer was developed. The "intonaco" was cut in a slice, step-by-step, approximately 1 mm behind the glue-facing of the painting, with sanding-discs. The glue used here had to be very heat-durable and highly elastic because of the high number of revolutions of the disc (up to 30'000/min.). A contact-glue of chlorinated-rubber basis, dissolved in trichlorethylalcohol was suitable. The painting could not be removed in one piece. The separate pictures of the cycle were thus transferred singly. The transfer by the proven method using epoxy-resin 410 and 554 with hardener 943 was carried out and the transferred paintings will be mounted on the north-wall, where in the lower parts no paintings remain.

Uncovering of the Byzantine paintings

The first task was the securing with paraloid 372 of the paint-layer, which was peeling due to tensions from the gum arabic applied by Lefebure. The gum arabic was then washed off with warm water. The areas of lime-wash were removed using the Airbrasive machine. The cleaned areas had to be continually fixed with silicate-ester. Loose areas of the remaining Renaissance painting were removed and stuck down with water-glass. The uncovering of the remaining areas, which first became accessible after removal of the Renaissance layer, showed to be very complicated. The plaster was grinded down with sanding-discs to the lime-wash, which lay on the paint surface. The thick areas of the sintered lime wash were reduced using grinding-heads; the thinner the layer, the finer the head used. The most difficulties arose by the red and black tones which had become loose from the sandy "intonaco". Here, one was forced to fix the paint-layer through the remains of the lime-wash. Unfortunately the penetration with paraloid was too low and not always gave satisfactory results. However the treatment with silicate-ester, which penetrated up to 3 cm. produced good results. This treatment had often to be repeated throughout the work, and

after enough fixing, the cleaning was continued using Airbrasive and ultrasonic instruments. The remaining crust of dirt could be removed easily with the paste developed by Prof. Mora. Retouching is at present not forseen by paintings of such quality. Pickholes and large areas of loss were closed with toned plaster. Extremely thin glazes may be applied later, should this be absolutely necessary.

Painting-technique of the Renaissance paintings

The red underdrawing and the actual painting were applied a fresco on the completely smooth surface, without any sinopia. Here is a case of a true "fresco-buono". Azurite was the only pigment to be applied in a glue binding-medium on the grey fresco underpainting. The following painting procedure corresponds fully to the Italian painting-technique of the Renaissance:

In areas for which metal-leaf was planned, the contours of the underdrawing were sketchily scratched out. The building up of the flesh tones is again Italian: Underdrawing/laying-in of the "verdaccio"/white high lights/glazes in a neutral tone/outlining of the contours/red of the cheeks.

Typical also is the single brush-strokes as on panel-paintings. The drapery, in contrast to the graphically handled faces and hands, are painterly modelled. At a closer look, it becomes immediately apparent that the work is that of several different hands. One was concerned with the heads and a second with the background, a third with the drapery. The halos were ornamented in accordance with the Italian methods, with punched designs and tin-inlays. The armour of Archangel Michael was likewise inlaid with tin-foil. The artists palette consisted of raw sienna; haematite; copper acetate; charcoal black; terra-verde; lime-white and azurite. The colours, except in flesh-tones, were applied unmixed; mixture-effects were achieved optically through laying-in different colours one on top of another. Also detectable is the enormous difference in quality fo the paintings; those in the choir being of much higher quality than the most likely stencilled paintings in the nave.

Two further works from the same school can be seen within a few kilometres away.

Technique of the Byzantine paintings

The very sketchy sinopia was drawn in on top of an already existing limewash. The approximately 2 cm. thick "intonaco" was completely smoothed over on the surface. Here, we have an example of a mixed tech-

nique; the underpainting of the background and the drapery are in "fresco-buono", where as the shading, flesh tones and high lighted patterns were applied "a secco". The range of pigments is very limited: charcoal black; raw sienna; burnt sienna; lime-white and vermillion. Except for the reddish-brown mixed tones, the entire colours were all applied unmixed.

Even without the exceptional Byzantine paintings, the chapel would still be a work of national importance due to the entirely of the paintings and the rarity of a complete Magdalene cycle of pictures.

Kurzfassung

Die Begräbniskapelle von Pontresina

Pontresina liegt im zum Kanton Graubünden gehörenden Oberengadin nahe St. Moritz.

Die Kapelle beherbergt Malereien aus 2 Epochen, eine byzantinische um 1150 und eine renaissance datiert 1495. An der Westwand liegen Byzantinische und Renaissance-Malerei übereinander. 1913 und 1934 gingen je eine Restaurierung voraus. Diese wurden unsachgemäss ausgeführt. Die Malereien wurden zerkratzt, nicht fertig freigelegt und entstellend übermalt. Durch Freilegung mit dem Hammer wurde die Malschicht vom Bildträger gelockert. Angebrachte Gummiarabicumfixierungen von 1934 bewirkten Oberflächenspannungen. Dadurch rollte das Original teilweise ab.

Probleme stellte das Erfassen der notwendigen Sanierungsmassnahmen. Durch Niveauveränderungen hervorgerufene Ausblühungen zerstörten die untere Hälfte der Malerei der Nordwand. Diverse bauliche Veränderungen brachten ebenfalls Substanzverluste.

Auf Kosten der Renaissancemalerei wurden Partien der byzantinischen freigelegt.

Konservierungsmassnahmen waren: Anlegen eines Entlüftungsschachtes, Horizontalisolierung, Dachreparaturen, Freilegen der neuentdeckten Bilder, Hintergiessen der Hohlräume, Entrestaurieren sämtlicher Malereien.

Probleme stellte die Abnahme der Renaissancemalerei über der byzantinischen. Nach Versuchen mit üblichen Verfahren musste für diesen speziellen Fall ein neues Verfahren entwickelt werden. Die abgelösten Bildteile werden an die Nordwand übertragen.

Dank der Qualität und Vollständigkeit der Ausmalung ist das Objekt von nationalem Interesse.

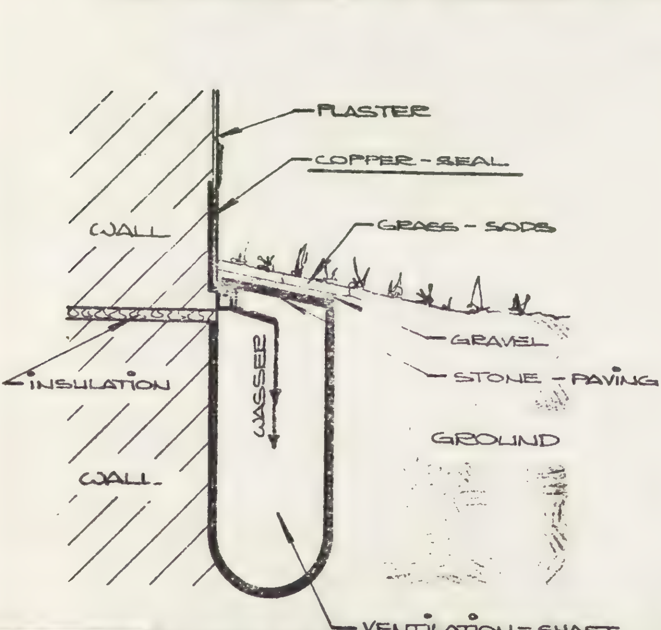
Abstract

The cemetery-chapel in Pontresina

Pontresina lies close to St. Moritz in Oberengadin, in the county of Graubünden. The chapel shelters paintings from two epochs; a Byzantine from 1150 and a Renaissance dated 1495. On the westwall, the Byzantine and Renaissance paintings lie one above the other. Improper restorations were carried out in 1913 and 1934; the paintings were scratched; incompletely uncovered and distortedly overpainted. The paint-layer became loose from its support, due to work with a hammer. Gum arabic, applied in 1934, resulted in surface-tensions, causing the original to peel. These problems showed the realty of the repairs. Mould-growth, due to changes in ground-level, destroyed the bottom half of paintings on the north-wall. Building-alternations also produced losses. Areas of the Byzantine paintings were uncovered at the cost of the Renaissance layer.

Conservation: laying of a ventilation-shaft; horizontal insulation; roof-repairs; uncovering of newly-discovered paintings; consolidation; re-restoration. Transfer of the Renaissance paintings produced problems. After testing with normal methods, a new system of transfer was developed. The paintings will be transferred onto the north-wall. The object is of national importance, thanks to the quality and completeness of the paintings.

PONTRESINA: VENTILATION – TUNNEL



MESURE DE LA PERMÉABILITÉ À LA VAPEUR D'EAU DE FIXATIFS UTILISÉS POUR LA RESTAURATION DES PEINTURES MURALES

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RESUME - On a mis au point une méthode pour mesurer le coefficient de perméabilité à la vapeur d'eau de produits utilisés comme fixatifs de surface en restauration de peintures murales. Ces produits sont appliqués sur des fragments d'enduits placés dans un dispositif adéquat, et on mesure par pesée la quantité d'eau évaporée en fonction du temps, sur l'enduit non traité d'abord, puis sur l'enduit traité. Le rapport des mesures donne la valeur du coefficient cherché. On commente les résultats pour les principaux produits employés en France dans ce domaine.

I - POSITION DU PROBLEME

Le Laboratoire de Recherche des Monuments historiques (LRMH) a établi un programme d'ensemble destiné à étudier les propriétés de tous les produits utilisés en restauration, et notamment les fixatifs de surface pour les peintures murales. Ces propriétés sont d'ordre physique ou chimique, et ont des conséquences sur les conditions de conservation des peintures.

L'eau joue un rôle important dans ces problèmes ; on s'est en effet aperçu que certaines peintures, traitées il y a dix ou quinze ans, ont été le siège d'altérations caractéristiques : soulèvement de la surface, cloques, entraînant souvent une partie du pigment. La cause de ce phénomène est la suivante : le mur contient une certaine quantité d'eau, qui tend à s'évaporer vers l'intérieur de l'édifice, donc à travers l'enduit peint. Si le film superficiel est imperméable, ou insuffisamment perméable, à la vapeur d'eau, cette évaporation ne peut se faire normalement, et provoque le soulèvement du film, avec phénomène d'arrachage analogue au "strappo".

C'est l'observation de ce phénomène qui nous a amenés à étudier de façon plus précise cette propriété ; il était nécessaire pour cela de mettre au point une méthode de laboratoire assez simple, et qui soit repro-

ductible pour pouvoir tester rapidement n'importe quel produit proposé par le marché. Cette étude est présentée ici ; elle a porté sur les principaux produits utilisés en France par les restaurateurs de peintures murales, auprès desquels une enquête a été effectuée. Il va de soi que les résultats donnés ici concernent uniquement la perméabilité, mais que pour porter un jugement définitif sur un produit, il faut tenir compte également de ses autres propriétés (apparence, vieillissement, etc...)

On a défini d'abord, de façon théorique, le coefficient caractéristique de la perméabilité d'un film, puis on a mis au point une méthode permettant de mesurer ce coefficient en laboratoire ; les mesures effectuées selon cette méthode permettent de tracer les courbes donnant sa valeur ; enfin, les résultats, portant sur une valeur moyenne, sont présentés dans un tableau d'ensemble qui donne une classification des produits testés en fonction de cette donnée.

II - PRINCIPE & METHODE DE MESURE

1) Théorie - Si l'on considère de l'eau s'évaporant de façon continue à travers un matériau poreux, constamment saturé en eau, cette évaporation est proportionnelle au temps ; la quantité d'eau évaporée pendant le temps t est

$q = c_o.t$ (1) où c_o est une constante dépendant des caractéristiques du matériau, de la surface d'évaporation, et des conditions thermo hygrométriques de l'air au-dessus du matériau (fig. 1 a).

Dans les mêmes conditions, si ce matériau est recouvert d'un film quelconque, celui-ci crée une résistance supplémentaire à l'évaporation, et on aura, pour le même temps :

$q' = k.c_o.t$ ou $q' = c.t$ (2) (fig. 1 b), où k est un coefficient uniquement dû au film. On voit que :

$k = c/c_o$ (3) . Nous appellerons k le coefficient de perméabilité du film.

Pour le mesurer, il suffit de comparer, quantitativement, l'évaporation de l'eau à travers un enduit, puis à travers le même enduit recouvert du film à étudier. Le rapport des deux mesures donne la valeur de k.

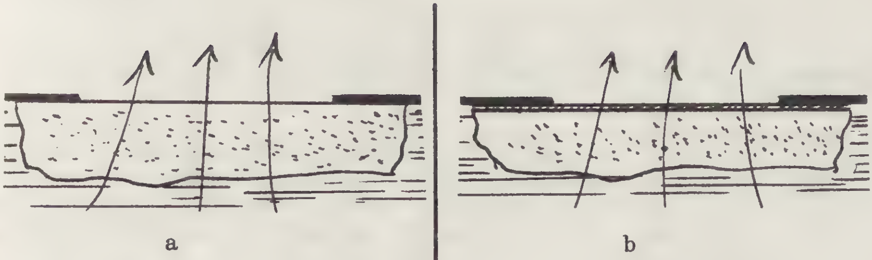

fig. 1

2) <u>Réalisation des mesures</u> -On a réalisé l'appareillage de la fig. 2. Un fragment d'enduit peint est placé sur une épaisseur de laine de verre (pour éviter tout phénomène biologique) imbibée d'eau, à l'intérieur d'une boîte en plastique dont le couvercle est ajouré suivant une ouverture rectangulaire de 4,5x3,5 cm, soit environ 16cm2. La surface de l'enduit appuie sur l'intérieur du couvercle, et est isolée de celui-ci par une feuille d'aluminium découpée aux mêmes dimensions ; le rôle de cette feuille est d'empêcher une évaporation éventuelle à travers le couvercle en plastique (v. plus loin : causes d'erreur). L'enduit peint étant ainsi enfermé, on place au-dessus (20 cm) une lampe de 100 W destinée à fournir de la chaleur. Celle-ci provoque l'évaporation continue de l'eau à travers l'enduit, et comme cedernier est en permanence imbibé d'eau à saturation, le phénomène s'établit de façon régulière (v. théorie, 1). La boîte avec son contenu est ensuite pesée régulièrement, ce qui permet de tracer la courbe représentant l'eau évaporée en fonction du temps ; on constate, comme on peut s'y attendre, que c'est une droite, du moins après un temps variable d'établissement d'un régime continu. La valeur absolue importe peu, seule est interessante la pente de cette droite : c'est le coefficient c_o (formule (1)), qui s'exprime en g/h.

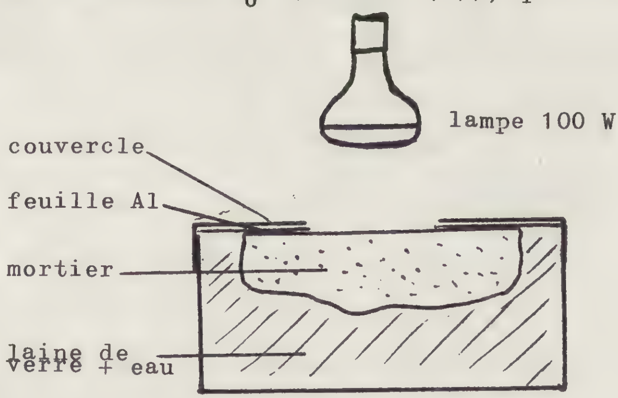

fig. 2
appareillage

Cette mesure est réalisée plusieurs fois, afin d'avoir une moyenne ; le fragment est ensuite sorti, sèché et reçoit une couche du film à tester, appliqué dans les conditions habituelles d'emploi (ou dans des conditions particulières dont on parlera plus loin). Il est à noter que l'enduit peint ne joue que le rôle de support, mais présente l'avantage de se rapprocher des conditions réelles d'emploi du film (c.à d. adhérence et éventuellement pénétration partielle de la couche picturale ou de la partie supérieure de l'enduit de chaux). Ces caractéristiques variant d'un mortier à l'autre, il importe de faire les mesures de c et c_o sur le même fragment. Par contre, un même produit peut être testé sur plusieurs fragments, ce qui permet de vérifier que la méthode est reproductible, et que les résultats ne dépendent pas des caractéristiques du support.

Une fois donc le film appliqué et sèché, on effectue la même série de mesures, ce qui donne la valeur de c, calculée par la pente de la droite obtenue.

Il suffit alors de faire le rapport c/c_o pour avoir le coefficient d'évaporation k. C'est un nombre abstrait inférieur à 1, qu'on peut exprimer en % : c'est le pourcentage de vapeur d'eau que laisse passer le film, par rapport à la quantité qui traverserait l'enduit si ce film n'existait pas.

III - RESULTATS

- Matériaux utilisés - On a employé des fragments d'enduits de provenance diverse, n'ayant plus d'usage en restauration. Leur origine est soit romaine (mortiers de fouilles) soit romane (chutes sans valeur). Leur dimension moyenne est de 10 à 15 cm de diagonale, et leur épaisseur de 1 à 3 cm environ. Une quarantaine de fragments ont été ainsi utilisés. Chaque produit a généralement été essayé plusieurs fois, afin d'assurer la reproductibilité des mesures et d'obtenir une valeur moyenne significative.

- Produits étudiés - Ont été expérimentés, selon cette méthode, les principaux produits utilisés en France par les restaurateurs de peintures murales comme fixatifs de surface. Leur nombre se monte à une dizaine.Dans le cas -fréquent- de produits commerciaux présentant plusieurs variantes, on s'est limité aux types les plus employés et ayant déjà fait leurs preuves comme fixatifs

Pour le choix de ces produits, une enquête a été effectuée auprès des restaurateurs d'une part, et auprès des fabricants d'autre part, afin de connaître les conditions habituelles d'emploi et la nature et les propriétés physiques et chimiques des produits. Il s'agit en général de résines de types acrylique ou vinylique, en solution ou en émulsion.

- Durée des essais - Cette limitation du choix des produits testés était nécessaire en raison du grand nombre de produits existant sur le marché ; en effet les expériences décrites plus haut sont plutôt longues : pour obtenir une courbe d'évaporation, il faut en moyenne une journée de mesures (6 à 8 heures) ; cette mesure étant faite trois fois, puis trois fois avec le film à étudier, et compte tenu des temps de sèchage entre les mesures, on voit que le temps nécessaire pour obtenir une mesure valable est assez important. De plus, comme il a été dit, chaque produit est généralement expérimenté plusieurs fois. L'appareillage utilisé, comportant plusieurslampes, permet d'effectuer plusieurs mesures à la fois. Il ne nécessite aucun équipement particulier, et peut être réalisé avec du matériel courant.

- Causes d'erreur -
- erreurs dues aux conditions ambiantes : un certain nombre de précautions doivent être prises. Un certain nombre de paramètre peuvent engendrer des causes d'erreur. Par exemple, l'évaporation se fait plus ou moins rapidement (toutes choses égales par ailleurs) selon les conditions thermo-hygrométriques de l'air au-dessus de la boîte, et le mouvement de cet air : un air froid et humide, et stable, provoquera une évaporation plus lente qu'un air sec et en mouvement. De plus, si plusieurs lampes fonctionnent en même temps et sont trop rapprochées, elles peuvent interférer, et la chaleur reçue par l'éprouvette située au centre n'est pas la même que celle reçue par une située sur le bord. Il faut donc veiller à ce que les conditions de l'expériences soient parfaitement reproductibles.
-erreurs dues au matériel : on a pu vérifier que l'évaporation à travers un couvercle plastique non ajouré est négligeable, surtout avec une feuille d'aluminium placée sous ce couvercle. La quantité d'eau évaporée, mesurée par pesée dans chaque expérience, est donc bien celle qui s'évapore à travers le fragment d'enduit.

Malgré toutes les précautions prises (conditions de température et d'hygrométrie stables, etc...) il subsis-

- te certaines causes d'erreur, d'origine indéterminée comme le montrent certains points aberrants trouvés dans les diagrammes. C'est pourquoi il est indispensable de faire toutes les mesures plusieurs fois.

Résultats obtenus- Produits testés

Ainsi qu'on l'a expliqué plus haut, on trace pour chaque série de mesures la droite représentant l'évaporation en fonction du temps, pour chacun des trois essais faits. La pente moyenne de ces droites donne c_o ; puis on obtient c de la même manière. La fig. 3 illustre cette mesure.

Le tableau donné en annexe regroupe les résultats obtenus pour les différents produits, en fonction de la concentration utilisée. On a souligné les conditions habituelles d'emploi.

On voit que les valeurs obtenues pour k varient de presque 1 à 0,4 ; les produits donnant cette dernière valeur sont les plus mauvais (rhodopas, paraloïd à plus de 10 %) ; ceux dont le coefficient s'approche de 1 sont les meilleurs (émulsions acryliques, V 45, paral. à 5 %).

Influence de la concentration : il importe de noter cette influence qui est très importante ; en effet un produit peut avoir une perméabilité satisfaisante à une certaine concentration, et pas à une concentration supérieure. La variation de k en fonction de la concentration utilisée n'est pas la même pour tous les produits, et n'est pas linéaire ; quand on élève cette concentration, k semble tendre vers une limite inférieure. Par exemple, le paraloid B72 ou B67 atteint un coefficient k de 0,40 à partir de 12 % (que ce soit 12, 20, ou 30 %). Vraisemblablement, on tend dans ces conditions vers la perméabilité du matériau plastique pur.

A partir de ces remarques, on peut tenter de définir une valeur critique de k, indépendante du produit, au-dessus de laquelle un fixatif serait considéré comme bon, et en-dessous comme mauvais. Cette valeur ne peut-être, actuellement, fixée qu'arbitrairement ; par exemple, il semble raisonable de prendre comme limite k = 0,6. Les produits se situant au-dessus de cette valeur seront alors considérés comme satisfaisants. On voit qu'un même produit peut être satisfaisant ou non suivant sa concentration.

Afin de disposer du maximum d'informations et de connaître en quelque sorte la marge de sécurité de chaque produit, on a effectué pour chacun d'eux : une mesure de k dans les conditions normales d'emploi, et une mesure à la concentration maximale, c!à d. dans un cas extrême : les différentes valeurs possibles sont toutes supérieures à cette valeur limite ; si celle-ci est satisfaisante, à fortiori le produit le sera pour toutes les conditions de concentration.

Enfin, pour quelques produits, on a effectué le calcul de k pour plusieurs valeurs de la concentration, pour voir l'évolution de k avec celle-ci.

Représentation graphique des résultats

Les fig. 4 et 5 représentent les principaux résultats obtenus. La fig. 4 montre la variation de k en fonction des divers produits. Les mesures sont ramenées à $c_o = 1$, ce qui donne k = c. La droite de pente 1 représente l'évaporation à travers un film de coefficient k = 1, les autres droites correspondent aux diverses valeurs de k. On a tracé en pointillé la droite correspondant à la limite arbitraire k = 0,6. Les produits situés au-dessus peuvent être considérés comme satisfaisants.

La fig. 5 montre l'influence de la concentration pour un même produit. On voit l'importance de ce facteur sur la variation de k.

IV - CONCLUSIONS

Les mesures qui viennent d'être décrites présentent une certaine importance dans la connaissance des produits employés en restauration, et dans leur choix. Car le phénomène de l'évaporation de l'eau à travers un film plastique joue un grand rôle dans la conservation des peintures murales, et il importe que les produits choisis présentent des caractéristiques déterminées, notamment en perméabilité.

Il est certain que ce critère seul ne suffit pas à porter un jugement sur un produit, et qu'une valeur satifaisante de k ne permet pas, à elle seule, d'accepter l'emploi de ce produit ; cette caractéristique doit être accompagnée d'autres mesures concernant les autres propriétés physiques du film (adhérence, brillance, tenue au vieillissement, à la lumière, etc...). Par contre, une valeur jugée mauvaise de la perméabilité doit suffire à exclure l'emploi d'un produit, car il peut alors en résulter de très graves altérations, dont nous avons parlé au début.

La méthode proposée peut naturellement être perfectionnée, et peut donner lieu à des variantes d'appareillage. Notamment, le contrôle des conditions thermo-hygrométriques de l'air où a lieu l'évaporation peut être amélioré de façon à éliminer toute cause d'erreur. Néanmoins il ne semble pas nécessaire de trop affiner la méthode, car les résultats cherchés n'auraient pas de signification pratique avec une trop grande précision.

Les résultats mentionnés ici ouvrent le champ à d'autres recherches : d'une part, la méthode a été expérimentée pour cette mesure, on peut donc, pour tous les produits susceptibles d'être employés, effectuer ce test de façon systématique (par exemple pour un nouveau produit apparaissant sur le marché); d'autre part, ces expériences seront complétées, au cours de nos prochains travaux, par les mesures des autres caractéristiques des films de fixatifs de surface, ainsi que par l'étude de leur tenue au vieillissement (cette dernière est déjà en cours). Par ailleurs, nous avons l'intention d'étendre ces recherches aux cas réels, au moyen de murs expérimentaux à la disposition du LRMH. Cette extension nous permettra d'établir de façon plus précise la valeur du coefficient critique défini plus haut arbitrairement. En effet, il sera possible de reproduire sur ces murs les phénomènes d'altération, et ainsi de déterminer la limite en question.

La poursuite de ces travaux constitue une recherche d'ensemble qui devrait permettre d'arriver à une connaissance parfaite, sur le plan scientifique, de tous les produits de restauration, et cela, les méthodes étant facilement comparatives, aussi bien en France que dans tous les pays qui travaillent sur ces problèmes.

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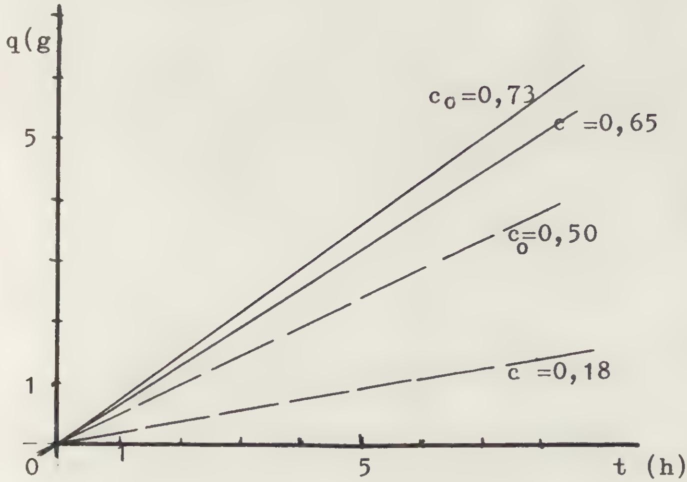

fig. 3

mesure de
k

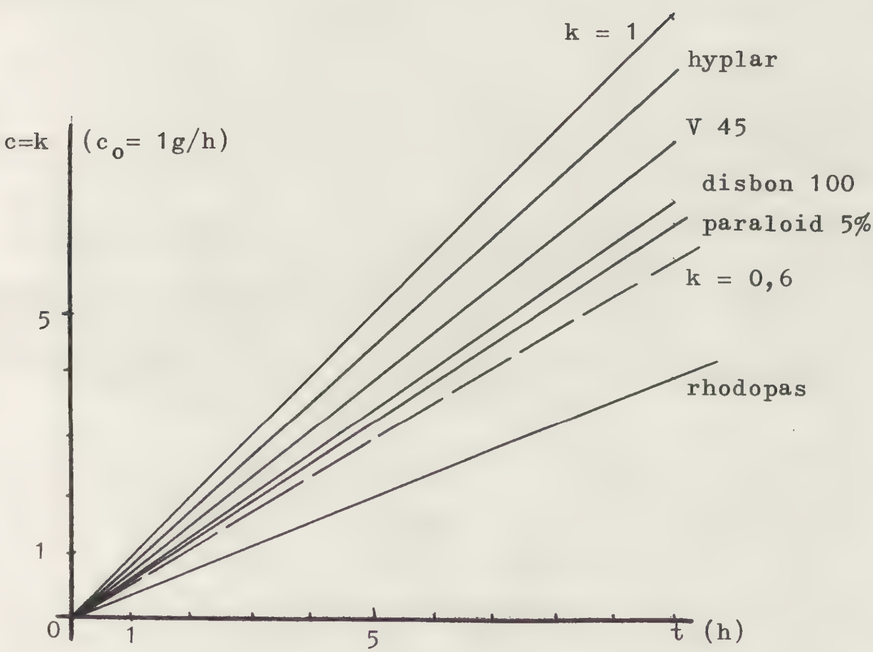

fig.4 – valeur de k suivant les produits

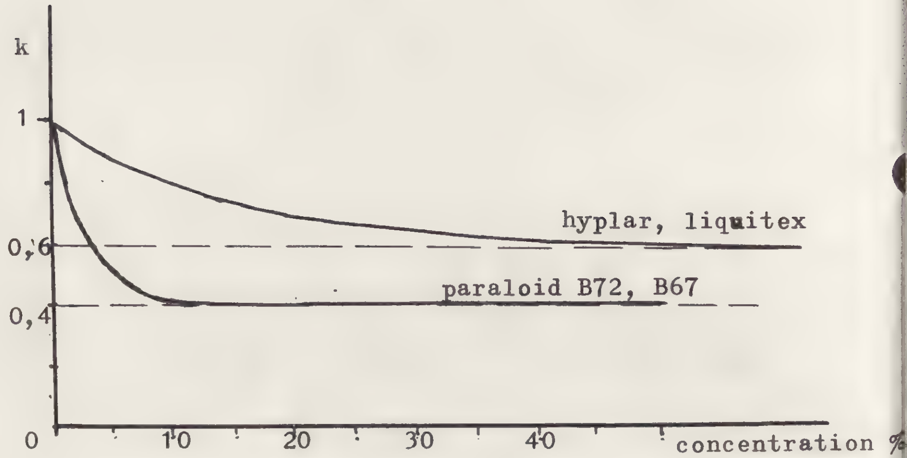

fig. 5 - Variation de k en fonction de la concentration.
On voit que k tend vers une limite qui dépend du produit, d'où l'importance de ce facteur: un même produit paut être bon ou mauvais suivant la concentration employée.

ANNEXE - TABLEAU RECAPITULATIF			
PRODUIT TESTE	NATURE	CONDITIONS D'EMPLOI	K
PARALOID B 72	acrylique en solution dans chlorotène	2 % plus de 12 %	<u>0,89</u> 0,40
PARALOID B 67	acrylique en solution ds chlorotène dans white spirit	plus de 12 % 50 %	0,40 0,40
RHODOPAS 5000	vinylique en solution dans alcool à 95 °	dilué	<u>0,44</u>
V 45	vinylique en solution dans alcool	dilué 5 %	<u>0,78</u>
DISBON 100	acrylique (dispersion)	dilué dans H20 5 à 10 % concentré 50%	<u>0,69</u> 0,60
HYPIAR	acrylique	dilué dans H20 5 à 10 % Concentré 50 % (d'origine)	<u>0,91</u> 0,60
LIQUITEX	Solution H2 0	Dilué Concentré 50% (d'origine)	<u>0,94</u> 0,70
GOMME ARABIQUE	Solution H2 0	Dilué H20 (2 %)	1

ÉVOLUTION DES TECHNIQUES DE SAUVETAGE ET DE CONSERVATION DES PEINTURES MURALES

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"Tout est impermanent"

Bouddah

Les peintures murales antiques, celles du Moyen-Age, et même des peintures plus récentes sont chaque jour menacées de destruction. Le sauvetage de ces documents nécessite une adaptation aux conditions du chantier des procédés traditionnels de dépose et de conservation : délais très courts, conditions climatiques extrêmes. Parmi les solutions possibles, nous avons expérimenté, préalablement à la dépose, l'imprégnation des peintures à l'aide de résines époxides. Le système de solidarisation des peintures mis en place après imprégnation est conçu de façon à éviter les contraintes chimiques, physiques et mécaniques. Cette méthode présente peut-être quelques risques, mais ils paraissent faibles comparés aux risques de destruction immédiate.

"All is unpermanent"

Bouddah

Antique mural paintings, those of Middle Ages and also more recent paintings, every day are menaced with destruction. Rescue of these documents requires an adaptation to conditions of yard of traditional processes of detaching and of conservation: very short delays, extreme climatic conditions. Among possible solutions, we have tested, previously the detaching, the impregnation of paintings by the aid of epoxide resins. The linking together of paintings placed after impregnation, is realized for avoiding chemical, physical and mechanical constraints. This method perhaps offers some risks, but they seem small compared to risks of immediate destruction

La destruction des sites archéologiques et historiques entrainent souvent la perte des peintures murales qu'ils récèlent. Comme pour les mosaïques, en présence d'engins mécaniques en action sur un site et lorsque tous les recours administratifs sont exclus, le "sauvetage" reste la seule solution.
Le sauvetage, c'est la dépose immédiate des documents dans n'importe quelle condition climatique : sous la pluie, par temps de gel ou de forte chaleur et quelles que soient les difficultés et les circonstances du chantier : en tranchée ou à 15 m de hauteur, sans eau, sans électricité, de nuit, au milieu des engins ou dans la boue. Le sauvetage ne peut se concevoir sans une adaptation à ces conditions particulières des procédés traditionnels enseignés à l'Istituto Centrale del Restauro ou au Centre de Rome et fort bien décrits par MM. Philippot et Mora dans le n° XI de Musées et Monuments (1).
La "dépose-sauvetage" d'une peinture murale est fonction de la nature et de l'état de conservation du document, de l'humidité ambiante, de celle du support, de la température, des conditions du chantier, des délais. Il y a vingt ans, nous avons utilisé les procédés traditionnels de dépose sans mesurer suffisamment l'importance de ces facteurs extérieurs. Cela nous a conduit à des résultats parfois décevants. Nous avons analysé les raisons de ces échecs et nous en avons tiré les leçons qui s'imposaient.
Une peinture murale peut avoir un support (2) sain constitué de couches dures et très adhérentes, fissuré ou non ; au contraire le support peut être de mauvaise qualité, altéré, très mince, pulvérulent, imprégné de sels solubles ; il peut être aussi le siège d'acitivité biologique ; il peut être partiellement sain, mais altéré par ailleurs ; il peut être

(1) UNESCO. Philippot et Mora, La Préservation des Biens Culturels, Musées et Monuments XI. 1969, P. 183
(2) Nous appelons "support" l'ensemble des couches d'enduit comprises entre le mur et l'intonaco

sain et tendre sur la plus grande surface, mais avoir été réparé ou contenir pour des raisons diverses des "rognons" ou des parties extrêmement dures. Les différentes couches qui le composent peuvent être fragiles, peu adhérentes les unes aux autres, ou encore soufflées. Le support peut être aussi fissuré, fragmenté, offrir en quelque sorte une infinité de pièges. La peinture sera soit une tempera, une fresque véritable, une peinture a secco, une peinture "mixte" (1). Le medium et les pigments constitutifs de la peinture peuvent être sains ou altérés. En présence d'éléments aussi variées et aussi difficiles, nous avons recherché une méthode et des procédés simples qui pourraient s'appliquer à la plupart des circonstances.

Nous avons classé les peintures murales en quatre groupes, en fonction de leur état de conservation :
1 - Support uniformément dur et sain, couche picturale saine
2 - Support uniformément dur et sain, couche picturale altérée
3 - Support altéré, couche picturale saine
4 - Support et couche picturale altérés

Le quatrième cas est celui qui présente apparemment le plus de difficultés ; on ne peut déposer que des couches picturales cohérentes. Dans le cas contraire, il faut au préalable restructurer les matériaux. Cette restructuration peut être obtenue à l'aide de produits de la chimie minérale ou de la chimie organique de synthèse. Après expérimentation, nous avons constaté une fois encore les multiples avantages des résines époxides (2). L'utilisation des résines époxides constitue un choix méthodologique qu'il convient de préciser. Les résines époxides sont considérées comme irréversibles à cause de la structure spatiale de leur groupement époxide. Bien que le vieillissement naturel ne puisse se comparer aux cycles artificiels, les essais de vieillissement artificiels sont satisfaisants. Comparativement aux autres grandes séries thermoplastiques et aux autres résines thermodurcissables, les époxides présentent la plus grande stabilité physique et chimique, les meilleures caractéristiques mécaniques, la meilleure résistance aux produits chimiques et aux ultra-violets. Certaines résines présentent cependant des fragilités chimiques qui permettent de les considérer comme réversibles dans certains cas.

(1) Ce terme "mixte" manque de précision : la technique de la plupart des peintures murales est fondée sur l'utilisation concomitante de fonds sur enduit frais ou sec et de peintures composées de pigments et de différents medium à base de chaux, de cires animales et végétales, d'oeuf, de lait, d'ail et d'oléagineux de type lin, ricin, oeillette. Nous pouvons rencontrer des peintures à la cire sur fond sec, des savons de cire et de chaux sur fond de fresque, des fresques véritables rehaussées de tempera et encaustiquées par la suite, etc..

(2) Epoxides, époxydes, époxy, éthoxyline.

Pour reprendre les termes d'un article paru dans Musées et Monuments XI (1) :

" La réversibilité est un principe sur lequel le "conservateur" doit "
" se montrer intransigeant ... Toutefois, lors de la restauration de "
" nombreux objets archéologiques, en particulier lorsque la consolida-"
" tion s'impose, une opération irréversible peut être admise à condi- "
" tion que les matériaux aient été d'abord soigneusement expérimentés "
" sur des pièces d'essai ".

L'imprégnation à l'aide de résines époxides a fait l'objet pendant plusieurs années, de longues séries expérimentales couronnées de succés, par exemple, par le Docteur Mülhethaler, R.A. Munikendam, le Professeur W. Domaslowski (2) et par nous-mêmes.
Pour conclure, l'utilisation de résines époxides pour la consolidation constitue un risque, mais un risque calculé : si elles sont irréversibles, elles sont stables. Si elles ne sont pas stables, elles seront obligatoirement réversibles. Mais en fait, il faut choisir entre la destruction immédiate du document ou le risque minime à longue échéance.

Aucune autre résine, aucune méthode traditionnelle ne permet de déposer une peinture murale humide considérée comme perdue, en quelques heures, dans les conditions climatiques, chronologiques et techniques citées plus haut. Pour parvenir à ce résultat, il faut choisir des procédés qui mettent en oeuvre une gamme de produits aux caractéristiques générales stables et aux caractéristiques particulières les plus diverses(3)

Pour pouvoir pénétrer dans le réseau capillaire du mortier de support ou entre les particules de pigments, il faut des résines à faible viscosité, à faible tension superficielle. Les résines d'imprégnation doivent résister à l'eau et aux produits chimiques ; elles doivent catalyser dans les capillaires humides gorgés de sels, souvent à des températures basses, catalyser vite ou lentement, catalyser sans retrait.
Les résines doivent avoir un noyau stable, posséder un coefficient de dilatation linéaire faible. Elles doivent être relativement transparentes, avoir un indice Gardner faible et un indice de réfraction qui, après catalyse, ne change pas le contraste des valeurs colorées. Elles doivent être, selon les circonstances, souples ou dures, réversibles ou irréversibles, mais toujours résistantes aux contraintes thermiques et aux micro-organismes. Le choix de la résine, du durcisseur et des adjuvants, le choix des formules sortiraient du cadre de cet exposé. Nous sommes encore dans un domaine expérimental où il n'existe pas de recettes. Nous indiquons en annexe à la fin du rapport quelques formules uti-

(1) UNESCO. La Préservation des Biens Culturels, Musées et Monuments XI, 1969, P. 329
(2) Domaslowski W. L'affermissement structural des pierres avec des solutions à base de résines époxides. I.I.C. 1970 New York, Conference on Conservation of Stone and Wooden Objects, p. 85
(3) Wihr R. Pratique du sauvetage et de la Conservation des Peintures murales. 6e Séminaire de l'A.T.M.- Trèves 1966.

lisées avec succés dans des circonstances déterminées.

LE SAUVETAGE DES PEINTURES MURALES EN PLACE - DEPOSE

L'opération préliminaire à toute dépose est d'abord l'organisation du chantier. Chaque fois que cela est possible, il faut échafauder, bâcher, installer l'eau, l'électricité, à l'aide d'un branchement ou d'un générateur. Il est parfois nécessaire de mettre en place des solins ou d'obturer des lacunes avec du plâtre ou un mortier léger facile à enlever ultérieurement. Il faut nettoyer le "champ opératoire", les murs, le sol, la peinture elle-même. Ensuite, particulièrement lorsque le contexte historique ou archéologique va être détruit, il faut observer soigneusement tous les éléments stratigraphiques existants. Le contexte architectural constitue une part importante de l'intérêt des peintures murales. C'est la raison pour laquelle il faut procéder avec le plus grand soin à la localisation, aux relevés photographiques, au dessin grandeur et au prélèvement d'échantillons. Les échantillons sont si possible analysés, toujours examinés à la binoculaire. Il faut mesurer ou estimer le pourcentage de porosité, contrôler le temps de pénétration dans une surface et un volume déterminés de 10 cc du solvant, vérifier le point de saturation, s'assurer que les solvants qui seront utilisés pour l'imprégnation ne sont pas nuisibles à la couche picturale. Avant de poursuivre les opérations, il faut procéder à un deuxième nettoyage très soigneux de la peinture. Cette opération dépend de la nature des substances à éliminer (1). Après le nettoyage, il faut éventuellement compléter les relevés et photographier à nouveau.

L'IMPREGNATION

Lorsque nous sommes en présence de peintures humides et si cela est possible, nous séchons les peintures. Le séchage a souvent pour conséquence la formation d'un voile dû à la cristallisation des sels solubles. Lorsque la dépose n'est pas un sauvetage, il est nécessaire de laver ces sels avant la dépose (2). Il est cependant possible d'imprégner des peintures humides ou salées ou bien encore des peintures humides et salées. Il suffit de choisir une formule appropriée. Comment faut-il utiliser la résine, qu'entendons-nous par imprégner ?
L'imprégnation ne consiste pas à obturer les pores ou les capillaires du matériau, ce serait une "plastification" qui modifierait l'aspect du matériau. Trop souvent d'ailleurs les imprégnations à l'aide de résines du type polyvinylique ou acrylique aboutissent à ce résultat, avec l'inconvénient que ces résines sont plus fragiles que les époxides et qu'une fois en place, il est difficile sinon impossible de les enlever totalement. Ceci interdit par la suite l'utilisation éventuelle d'autres procédés. Nous appelons imprégnation la saturation des capillaires du matériau par une solution de résine époxide catalysée. Le pourcentage de résine et de solvant, la quantité totale de solution mise en oeuvre pour

(1) Philippot et Mora. Op. cit.
(2) Bassier Claude. Eine methode zur Konservierung antiker Wandmalerein A.T.M.Mannheim 1974.

une surface donnée, doivent être exactement calculés de façon que, après évaporation du solvant, la résine catalysée en place crée uniquement des "ponts" entre les particules constituant le mortier sans jamais obturer, bloquer les pores et les capillaires de ce dernier. On parvient à ce résultat parce que la faible tension superficielle de la solution permet une bonne pénétration et une bonne distribution de cette solution ; ensuite, lorsque le solvant s'évapore, la tension superficielle de la résine catalysée devient plus forte, la résine tend à se regrouper en adhérant fortement aux particules élémentaires constitutives du matériau imprégné.

COUPE AVANT IMPREGNATION — EN COURS D'IMPREGNATION — APRES CATALYSE DE LA RESINE

La quantité de résine utilisée, calculée en fonction de la porosité du matériau de support,est toujours très faible. Dans certains cas, les essais préalables montrent que sur certains matériaux la pénétration de liquide en surface est très faible ou nulle. L'imprégnation proprement dite est mise en oeuvre de la façon suivante :préalablement à l'imprégnation, nous imbibons la peinture et son support jusqu'à saturation à l'aide du solvant qui servira à préparer la solution de résine (1). La formule de la résine est choisie en fonction des circonstances précédemment exposées ; les constituants sont pesés et mélangés ; la résine est dissoute à des taux variant de 1 à 5 % de résine par rapport au solvant. Les solvants utilisés sont des solvants polaires ou non polaires, le plus souvent des mélanges de solvants et de diluants, parfois de diluants réactifs. Les solutions de résines sont appliquées au pistolet ou par gravité entre la surface de la peinture et un écran imperméable. Il est possible de "rincer" délicatement la surface avec un solvant à faible tension superficielle passé au pistolet. Une catalyse longue à température moyenne est souhaitable. En cas de nécessité, il faut utiliser des accélérateurs et chauffer aux infra-rouges, ce qui nuit à la qualité de la résine catalysée. Il faut effectuer prudement les opérations d'imprégnation à cause des risques biologiques et des dangers d'explosion qui résultent principalement de l'utilisation des solvants. Les techniciens doivent être munis de combinaisons, de gants, de cagoules à masque autonome. Il faut utiliser un explosimètre, des ventilateurs, et avoir à portée de la main des extincteus à neige carboni-

(1) Il existe actuellement des résines époxides qui catalysent dans l'ea
Nous étudions la possibilité d'utiliser ces résines pour imprégner
des enduits à l'aide de solutions aqueuses.

que. L'imprégnation devra être conduite de manière à retarder la remontée d'humidité rémanente. A l'aide d'un chauffage infra-rouge ou à air pulsé, il va être possible d'obtenir un degré de siccité suffisant pour entoiler la peinture.

ENTOILAGE

Lorsque la cohésion de la couche picturale est assurée, soit naturellement, soit par imprégnation, il faut assujettir la peinture à un système qui maintienne sa cohésion structurale pendant la dépose. Comme pour les mosaiques, ce système est constitué par un adhésif et par une armature souple ou rigide.

L'adhésif

Nous avons renoncé à la colletta (1) pour plusieurs raisons :

1 - La colletta agit par adhérence et par la contrainte résultant du retrait. Nous tenons surtout à éviter des contraintes tangentielles. D'autre part, nous n'effectuons jamais de strappo, mais des stacco, c'est-à-dire que nous enlevons toujours au cours des déposes-sauvetages, la pellicule peinte, l'intonaco, souvent tout ou partie de l'arricio. Dans cette optique, la colletta ne s'impose pas.
2 - Il est parfois difficile d'éliminer la colletta de tous les pores du matériau altéré. Lorsque le support contient des germes pathogènes, la colle s'altère ; l'altération peut gagner la peinture. Certains produits chimiques transforment la colle en collagène insolubles ; ceci limite ou interdit l'usage de certains produits sur la face arrière de la peinture déposée.
3 - Il est difficile de faire sécher cette colle en atmosphère humide et froide.
4 - Pour des raisons administratives, il arrive parfois que les crédits nécessaires à la conservation et à la restauration d'une peinture déposée ne soient accordés que deux ou trois ans après la dépose. Il est impossible de conserver une peinture entoilée avec de la colletta pendant trois ans, sans risque de destruction définitive.

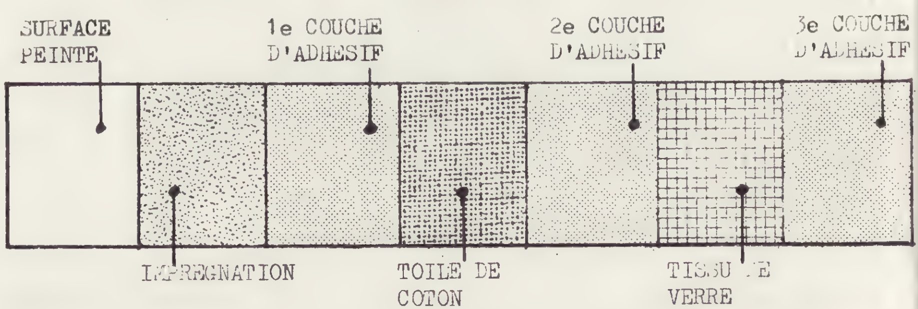
Nous préférons utiliser des adhésifs de la série vinylique ou acrylique qui conviennent tout à fait comme matériau de transfert provisoire. Il faut toujours y ajouter avant l'emploi un agent bactériostatique approprié, sans danger pour les peintures.
Pour les peintures des groupes 1 et 2 (C.F. notre classification en page 2), nous utilisons une dispersion de copolymère acétate de vinyl-ester-maléique de type anionique, réversible au gel et filmogène à + 3°C. Le film très résistant, très souple, est insoluble à l'eau. Le séchage de cet adhésif ne provoque aucun retrait. Lorsqu'il est sec, son adhérence n'est pas altérée par l'humidité rémanente.

(1) colletta . Phillipot et Mora. La Conservation des Peintures Murales, Musées et Monuments XI. UNESCO P. 204

Pour les peintures des groupes 3 et 4, nous préférons utiliser un alcool polyvinylique à indice d'estérification moyen, présentant un taux d'hydrolyse de 80 %. Il possède une viscosité de 1000 cp. pour une solution dans l'eau à 10 pour cent et à 20°C. Le film possède un allongement de 300 pour cent pour une résistance à la traction de 4,5 K/mm2. Il est uniquement soluble à l'eau froide. Le séchage de cet adhésif ne provoque aucun retrait. Ses qualités d'adhérence après séchage ne sont modifiées que pour une humidité rémanente relativement importante.

L'armature

La mise en place d'une armature souple c'est l'entoilage. Il est constitué par l'application d'une couche d'adhésif, la mise en place de carrés de 0,40 x 0,40 mètres de toile de coton désensimée, d'une nouvelle couche d'adhésif et d'un tissu de verre en toile Roving de 150 grammes au mètre, présentant une résistance de chaine et trame de 110/120 Kg pour une bande de 5centimètres de large. Ce tissu est posé sous la forme de bandes croisées de 0,20 mètres de large. L'entoilage est achevé par une dernière couche d'adhésif. Le séchage est obtenu par un générateur d'air chaud de chantier de 25.000 calories.
Lorsqu'on est confronté avec les peintures des groupes 1 et 2, c'est-à-dire à support dur, il est impératif d'éviter les réactions de démolition du mortier sur la couche peinte. Il faut solidariser provisoirement cette dernière à un support provisoire rigide qu'il sera facile d'éliminer après la dépose. Pour cela nous appliquons sur l'entoilage précédemment décrit, une couche de 1 mm d'épaisseur de mortier de sable, de bentone et de copolymère vinyl-ester-maléique et nous séchons. A ce stade, nous effectuons éventuellement le tracé des éléments et le découpage de la peinture perpendiculairement à la surface. Puis nous scellons sur l'entoilage des panneaux en "latté" à l'aide de mortier de résines époxides de consistance crémeuse, thixotropé pour éviter qu'il ne coule. Sur des surfaces courbes, nous utilisons des structures en nids d'abeilles pour former des supports rigides, résistants et légers, adaptés à la courbure de la paroi. Pour les peintures murales des groupes 3 et 4, nous procédons comme pour les revêtements de mosaïque : nous dissocions l'entoilage souple de la confection d'un moule rigide qui sert à assurer la position de la surface peinte sur un volume.



LA DEPOSE

La cohésion de la couche picturale et du support est maintenant assurée d'une manière naturelle ou grâce à l'imprégnation. Nous avons installé sur la peinture un système destiné à fromer avec la peinture une structure unique, cohérente, souple ou rigide que nous allons pouvoir déposer. Comme pour les pavements de mosaïque, la dépose est conditionnée par l'intérêt du document, ses dimensions, son transport et son stockage éventuel. Grâce à la très grande solidité du système de solidarisation, il est possible de déposer des éléments de très grande dimension, éventuellement très lourds. Nous avons déposé à Bordeaux des peintures de 32 m2 de surface en un seul élément. Mais souvent les contraintes administratives et financières nous obligent à transporter et stocker les documents pendant plusieurs années. Il faut donc les découper perpendiculairement à la surface, jusqu'au mur pour avoir des éléments normalisés de 1,00 x 1,50 mètres ou de 1,50 x 3,00 mètres. Cette opération est beaucoup moins nuisible pour une peinture que pour une mosaïque car après restitution, elle est quasi invisible. Il faut accorder quand même le plus grand soin à cette opération. En particulier, il faut numéroter, repérer les éléments entre eux, par rapport à un niveau et une verticale de référence, enfin, établir un plan de dépose.

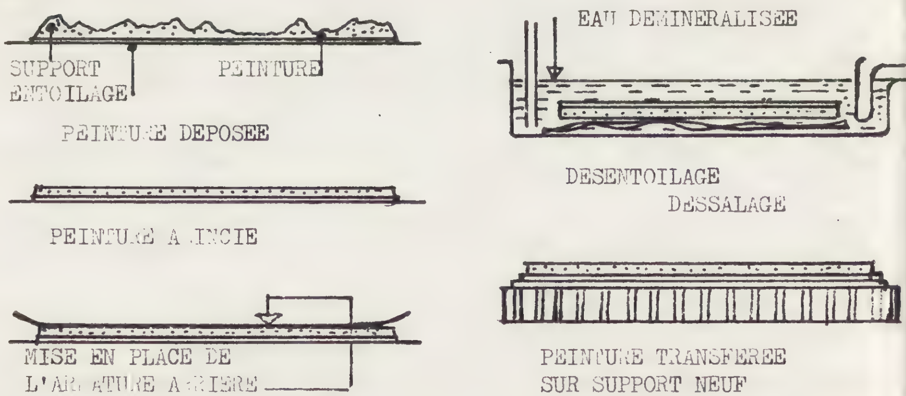
ENLEVEMENT DE LA PEINTURE

En premier lieu, il faut prendre soin de fixer solidement la partie supérieure du système de solidarisation qui maintient la peinture. La séparation de la peinture du mur de support peut présenter différents types de difficultés ; dans quelques cas, il suffit de marteler la surface entoilée à l'aide de marteaux en caoutchouc pour l'obtenir. D'autres fois, il faut utiliser les plans de stratification que l'on rencontre entre les différentes couches d'enduit pour obtenir la séparation. Certaines peintures sont fixées sur des mortiers très durs, dont les couches, très adhérentes entre elles, sont solidement accrochées au mur. On rencontre aussi toutes sortes de cas intermédiaires qui sont parmi les plus difficiles à traiter. Dans les trois dernières circonstances, il est nécessaire d'utiliser des lames d'acier pour séparer la peinture du mur. Ces lames sont de nature et de longueurs différentes suivant le cas; la longueur des lames varie de 0,10 à 3 mètres, la largeur de 3 à 6 centimètres. Nous utilisons des lames souples, semi rigides, rigides ; des lames dont le tranchant est en bout ou latéral, des lames à tranchant droit ou dentelé. Elles peuvent être utilisées manuellement ou de préférence à l'aide d'outils électriques et pneumatiques vibrants.
Les éléments sont déposés en fonction de leurs dimensions, soit à plat sur des panneaux semi-rigides, soit enroulés sur des c lindres de grand rayon de courbure. Il faut toujours interposer une couche de matériau souple du type mousse de polyéthylène entre la face arrière de la peinture déposée et tout autre élément.

SAUVETAGE - CONSERVATION

Dès que les documents sont en atelier, il faut les sécher, les désinfecter, si nécessaire les remettre soit à plat, soit en forme sur leur support moulé. Le traitement de conservation va consister à enlever les ves-

tiges de l'ancien support, dresser la face arrière des peintures, et la fixer ; éventuellement laver et fixer les sels solubles. Toutes ces opérations sont bien connues. Nous préciseront seulement quelques aspects intéressants qui découlent directement du procédé de dépose, par exemple pour des peintures imprégnées de sels.
La partie arrière de la peinture est débarrassée des vestiges de l'ancien support de façon à ne conserver que l'intonaco et si cela est nécessaire, quelques millimètres de la couche d'enduit inférieur, l'arricio, au total 2 à 3 millimètres maximum d'épaisseur. En fonction de la nature exacte du mortier, des sels, et du résultat de l'imprégnation, nous procédons à une nouvelle imprégnation. Les lacunes sont comblées à l'aide d'un mortier de chaux léger de composition et d'aspect identique à l'arricio d'origine. Puis toute la surface est couverte d'une couche de 1 à 2 millimètres d'épaisseur d'un mortier de sable de silice et de résine époxide fluide. Sur cette couche, avant catalyse complète, nous appliquons un tissu de verre Roving léger préimprégné de résines époxides. Après catalyse, nous mettons les éléments à tremper dans de l'eau froide déminéralisée. Le lavage est suivi de la perfusion d'une solution à 1/10.000e de fluo-silicate double qui a pour objet de fixer les derniers sels solubles et de désinfecter puissamment les matériaux du support. En une seule opération nous procédons au désentoilage et au dessalage. Ce résultat peut être obtenu parce que l'imprégnation telle que nous la pratiquons n'est pas une plastification ; elle laisse les pores et les capillaires du mortier libres. Les résines époxides n'entourent pas les cristaux salins d'une membrane étanche, donc, ils sont solubles. L'eau est sans action sur les sables et sur les pigments qui sont insolubles. Le système mis en place sur la face arrière de la peinture est poreux ; il laisse passer l'eau et malgré cela il est très résistant. Lorsque l'adhésif du système de solidarisation mis en place avant dépose est dissous, et que, par conséquent, ce système cesse sa fonction, c'est la résine époxide et le tissu de verre mis en place sur la face arrière qui prennent le relais pour la cohésion et la résistance. Les peintures ainsi traitées sont considérées "en condition de conservation" (1).



(1) Nous avons utilisé bien d'autres méthodes efficaces pour le sauvetage ; par exemple : imprégnation époxide, barbotine d'argile, plâtre armé, ou bien : imprégnation époxide, latex armé de tissu de verre, mousse de polyuréthane, etc.

RESTAURATION

Nous transférons les éléments de peintures en condition de conservation sur des supports légers composés d'une âme en nid d'abeille d'alliage léger prise en sandwich entre deux feuils de tissu de verre stratifiés de résines époxides. La liaison entre la peinture et le sandwich est constitué par un mortier de sable calcaire fin et d'une émulsion de résine de type vinylique résistant à l'eau. Ce mortier souple absorbe les différences de coefficient de dilatation entre la peinture et le sandwich. Il sert de couche d'intervention. Il arrive à durcir parce que l'humidité du mortier peut s'évaporer à travers les capillaires libres de la peinture. La plupart du temps, le désentoilage n'a pas lieu avant transfert sur un support, mais après. Le désentoilage est effectué comme nous l'avons dit précédemment par simple trempage dans de l'eau légèrement déminéralisée. Il est tout à fait remarquable que les toiles du système de solidarisation soient absolument blanches après leur enlèvement, comme avant leur mise en place. Grâce au procédé de sauvetage mis en oeuvre, nous obtenons un coefficient d'efficacité à la dépose étonnant. Nous avons constaté sur les bords des lacunes, la perte de quelques petites écailles, au maximum 20 à 30 millimètres carrés par mètre carré de surface déposée. Ce procédé permet donc le sauvetage des documents dans toute leur intégrité, sans aucune perte. Il n'est pas nécessaire d'effectuer de repeints ou de restitutions, sauf pour d'éventuelles nécessités de présentation et de lisibilité. Leur aspect est plus beau qu'avant la dépose. L'enlèvement des sels redonne tout leur éclat aux couleurs. L'indice de réfraction des résines utilisées fait disparaitre, s'il existe encore, le "voile" que l'on constate parfois sur les peintures.

CONCLUSION

Nous rappellerons pour terminer ce que nous avons dit au sujet des mosaïques : le sauvetage, la dépose, la conservation des peintures, sont des opérations de fouilles et de recherche archéologique ou historique. Elles nécessitent une analyse très fine du document. Les renseignements recueillis à cette occasion sont enregistrés sur des fiches analytiques normalisées. Lorsque ces fiches seront suffisamment nombreuses, elles permettront une connaissance moins superficielle des peintures murales. Grâce à l'adaptation que nous venons de décrire de la méthode traditionnelle de dépose et de conservation, nous essayons de limiter la destruction de ces documents. Le procédé présente des avantages, mais aussi des inconvénients ; c'est la raison pour laquelle nous avons pris le maximum de précautions en fonction de l'état actuel de nos connaissances. Toutes les résines utilisées pour l'imprégnation ont fait l'objet d'études comparatives avec d'autres produits. Nous avons imprégné des blocs de craie à l'aide de polyesthers, de solutions et d'émulsions vinyliques et acryliques diverses, d'huile, de lin, de vernis à base de damar, candelila, carnauba, cires naturelles, standolies, etc ... Nous avons soumis ces échantillons à un rayonnement ultra-violet intense pour un spectre compris entre 2800 à 4000 A° pendant trois mois consécutifs. Seules les imprégnations époxides n'ont pas changé de couleur (moins de 0,2 de l'indice Gardner), ni de caractéristiques physiques et mécaniques. Malgré

ces précautions, il y a toujours un risque si minime soit-il ; les résines de type aliphatique présentent une faible sensibilité à l'eau et à certains acides que l'on ne rencontre pas, il est vrai, d'une manière courante. Les Musées n'ont-il pas, entre autre mission, celle de préserver des agressions physiques et chimiques les documents d'Art et d'Histoire qui leurs sont confiés ? Devant les innombrables causes de destruction qui menacent les peintures murales, il fallait faire un choix. Nous l'avons fait ; nous en prenons la responsabilité. De toute manière, ceci n'est qu'une expérience ; la recherche continue.

C. BASSIER

ANNEXE

Formules de résines époxides pour imprégnation
Marque Araldite - Fabricant CIBA - GEIGY. Bâle.
Quantités indiquées en parties-poids:

Résine	Durcisseur	Adjuvant
AY 101 100 PP	HY 951 5/6 PP	
AY 101 100 PP	HY 956 10/12 PP	
AY 121 100 PP	HY 951 4/4,5 PP	
CY 221 100 PP	HY 837 25 PP	Silane A 186 1 PP
GY 250 100 PP	X 157 2273 15 PP	
DY 022 100 PP	HY 2954 45 PP	
LY 554 100 PP	HY 554 20 PP	

Exemple de solvant : Toluène : 80 PP Alcool à 95° : 20 PP

Exemple de dissolution : Résine : 3 PP Solvant : 100 PP

ÉVOLUTION DES TECHNIQUES DE SAUVETAGE ET DE CONSERVATION DES PAVEMENTS DE MOSAIQUE ANTIQUE

Claude Bassier

Masseroux ATUR 24000
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France

" ... Et il arrive malheureusement encore "
" aujourd'hui que des efforts déployés pour "
" préserver et restaurer des biens culturels "
" aboutissent à des catastrophes ... "
"..les résultats..auraient pu être meilleurs "
" si l'on avait eu recours à des techniques "
" et à des matériaux modernes "

UNESCO. Centre de ROME, La Préservation des Biens Culturels, Musées et Monuments XI, 1968, Avant-propos, page 5.

En France, depuis vingt ans, nous sommes confrontés avec un problème dramatique pour l'archéologie : l'expansion de l'agriculture, les travaux de constructions urbaines et de voies de circulation. Dans 90 % des cas, ils ont pour conséquence la destruction de la connaissance et des documents d'archéologie, d'Art et d'Histoire.
Grâce à une prise de conscience et un effort financier important du Ministère des Affaires Culturelles, nous avons été appelés à participer au sauvetage de certains documents. Pour sauver les mosaïques et les peintures devant les bulldozers, ou les pelles mécaniques, il fallait des techniques adaptées aux circonstances, rapides et efficaces. Nous avons déposé des pavements de mosaïque dans des conditions climatiques très diverses et souvent excessives : sous la pluie, en plein soleil au mois d'Août, dans des fouilles innondées, au mois de décembre par - 18°C. Une seule constante : des délais impérativement très brefs. Nous avons rencontré toutes sortes de mosaïques et de supports; des bétons très durs, très épais, fracturés, effondrés, supportant des tessères recouvertes de concrétions ou, à l'inverse, altérées, destructurées, inconsistantes. Nous avons eu à traiter en outre des mosaïques conservées dans des Musées, qui avaient subi une ou plusieurs restaurations antérieures et se trouvaient cependant en très mauvais état.
En dix ans, nous avons sauvé plus de 170 pavements de mosaïque. Comment avons-nous procédé ? Après avoir utilisé les recettes tradition-

nelles et mesuré leurs inconvénients, nous avons fondé notre méthode sur l'analyse des documents, de leur structure, des matériaux qui les composent et des processus de dégradation. Nous avons étudié les conditions des chantiers en fonction des résultats que nous voulions obtenir. Nous avons aussi systématiquement essayé, expérimenté les outillages et les nouveaux matériaux susceptibles de donner les meilleurs résultats ; en particulier, des centaines de produits de la chimie organique de synthèse. Le but de nos recherches était la définition de méthodes spécifiques pour la dépose et pour le transfert de pavements de mosaïque à l'occasion des sauvetages. Par sauvetage, nous entendons des interventions d'urgence dans des conditions diverses et difficiles. Les procédés de dépose utilisés dans ces conditions peuvent bien entendu être appliqués dans d'autres situations. Les procédés de dépose conditionnent en partie les procédés de transfert. Les résultats catastrophiques de certains procédés de transfert traditionnels nous ont conduit à repenser cet aspect de la conservation des mosaïques. Voici comment nous avons provisoirement résolu quelques uns des problèmes posés.

SAUVETAGE DE PAVEMENTS ANTIQUES EN PLACE - DEPOSE.

Les pavements de mosaïque périssent par l'altération propre des tessères qui les constituent, mais le plus souvent par la ruine du support ou par l'altération de la liaison entre le tapis de tessères et le support. Alors qu'une mosaïque aura traversé des siècles sans dommage, c'est à partir de l'instant de sa découverte qu'elle va courir le plus grand risque de destruction. C'est pourquoi, je me permets de rappeler aux fouilleurs trois importantes règles de sauvegarde à l'occasion de la découverte d'un pavement :

1 - Réaliser des solins tout autour des limites du pavement et obturer toutes les petites lacunes à l'aide de plâtre faible ou de mortier de chaux léger, jamais de ciment.
2 - Protéger la surface par une couche de sable fin de 2cm à 3cm d'épaisseur. Dans le cas où le document risquerait de passer une saison froide sans protection, mettre sur le sable 5cm de terre par degré de température au-dessous de zéro. Proscrire les films plastiques parce qu'ils bloquent l'humidité, les racines, et les insectes fouisseurs au niveau du tapis de tessères et contribuent ainsi à la destruction de la mosaïque. Proscrire la paille, les sacs et les corps organiques qui se décomposent, altèrent la mosaïque sans la protéger réellement de l'humidité et du gel. L'humidité n'est pas dangereuse en soi. En présence de températures négatives, elle est catastrophique.
3 - Chaque fois que cela est possible, faire au moins sur un côté de la mosaïque un drain plus profond que le <u>statumen</u> : le hérisson.

Aujourd'hui, malheureusement, les structures antiques sont le plus souvent mises au jour à l'occasion de découvertes fortuites. Elles ont pour origine l'intervention d'engins mécaniques de terrassement. A ce stade, sur le plan administratif et sur le plan technique, lorsque tout n'a pas été détruit en quelques heures ou en quelques minutes, la dépose est l'opération indispensable au sauvetage d'une peinture ou d'une mosaïque. On doit lui accorder des soins tout particu-

liers car elle conditionne la bonne conservation ultérieure de la mosaïque (1). Préalablement à la dépose, nous effectuons avec la plus grande précision tous les relevés, prélèvements, analyses et essais nécessaires. Si cela est possible, nous échafaudons et bâchons largement au-dessus et autour de la mosaïque. Si le pavement est recouvert de concrétions dures et irrégulières, il est nécessaire de les éliminer par ponçage avant dépose, faute de quoi l'entoilage fixerait les concrétions et les tessères non fixées risqueraient de se disloquer au cours de la dépose. Parfois un traitement chimique léger est suffisant. Lorsque le matériau des tessères est altéré, qu'il est pulvérulent ou savonneux, il est indispensable de le traiter avant dépose. Si la pellicule superficielle est altérée d'une manière irréversible, il faudra procéder à son ablation . Parfois, il suffit de renforcer la structure altérée du matériau constitutif des tessères. On peut envisager la fixation des sels solubles, la transformation des carbonates ou le "pontage" entre les cristaux. Première méthode : après avoir lavé le pavement à l'eau déminéralisée additionnée de 1 % d'agent tensio-actif non ionique, nous traitons à l'aide d'une solution de fluo-silicate à 1/10.000e, puis à 1/1.000e avant de rincer à l'eau pure déminéralisée. Deuxième méthode : nous imprégnons la surface des tessères à l'aide de solutions de résines réactives de type époxides à très faible viscosité et à faible tension superficielle. La quantité de résine et le rapport résine/solvants sont calculés de façon à ce que seuls subsistent après évaporation du solvant et catalyse de la résine, des "ponts" synthétiques entre les micro-cristaux dissociés. Nous traiterons plus longuement du problème des imprégnations dans la partie consacrée à la conservation des peintures.
Lorsque la cohésion du matériau constitutif des tessères est assurée, il est possible de procéder à l'entoilage sans risque de désolidarisation en cours de dépose. Une bonne dépose est conditionnée par la mise en place sur le <u>tesselatum</u>, sur le tapis de tessères, d'un système qui assure la solidarisation, la cohésion des tessères dans le plan du pavement. Ce système doit être déterminé en fonction des circonstances du chantier, des caractéristiques physiques et mécaniques des matériaux et non d'après des "recettes" ; il est constitué essentiellement par un adhésif et une armature souple ou rigide.
Dans les manières d'opérer, les "recettes" traditionnelles, l'adhésif est une "forte colle animale", les armatures : soit de nombreuses toiles légères, une forte toile de jute, ou encore de multiples couches de papier ... Certes la colle d'os possède une bonne adhérence, mais elle est difficile à préparer, elle ne s'applique qu'à chaud, elle refroidit et coagule trop vite sur un support froid. Elle ne peut pas s'appliquer sur des supports humides. Elle est longue à sécher. Son retrait produit des contraintes dangereuses pour le document. Si elle n'est pas entièrement éliminée à la fin de l'opération de restauration, elle peut constituer des foyers d'infection pour le document. Il est impossible de conserver et de stocker sans risque pendant longtemps des mosaïques entoilées avec cette colle.

(1) BASSIER (Cl.), Conservation des pavements de mosaïque antique en France, Actes du IIe Colloque International de l'AIEMA, 1971.

Les colles synthétiques les plus fréquemment utilisées à la place de cette colle d'os sont à base d'esters vinyliques. Les caractéristiques des colles de cette série sont fonctions de la nature du polymère, de son degré de polymérisation, de sa présentation. Les hauts polymères sont durs, cassants, peu adhérents. Les polymères moyens sont plus adhérents. Les solutions sont plus adhérentes que les émulsions. Elles sont plus difficiles et dangereuses à mettre en oeuvre. Elles sont difficiles à enlever ; leur dissolution présente des dangers physiologiques et des risques d'accidents. Les émulsions sont plus faciles à mettre en oeuvre. Les émulsions plastifiées sont plus adhérentes et plus souples. Elles sont filmogènes à plus basse température, mais irréversibles au gel. Mais la technologie des adhésifs vinyliques pourrait à elle seule faire l'objet d'une étude spécialisée.
En résumé, sous réserve des conditions du chantier et d'une connaissance approfondie des produits, on peut utiliser des adhésifs de type vinylique pour entoiler des mosaïques. Une exclusion absolue : les supports humides ou avec humidité rémanente. Dans certains cas, on peut cependant utiliser ces types d'adhésif, même sur des supports humides à condition de savoir et de pouvoir effectuer toutes les opérations de dépose selon un minutage extrêmement court et précis. Seule une grande expérience permet ce type d'"exploit" qui n'est jamais sans risque. Les colles de cette série qui nous ont donné le plus de satisfaction sont des mélanges d'émulsions d'acétate de polyvinyle non plastifié et de dispersion de copolymère acétate de vinyle ester maléique. Grâce à ce type d'adhésif, nous avons pu déposer une mosaïque à l'emplacement du tunnel autoroutier de Choulans à Lyon par une température extérieure de - 18°. Il faisait une température positive de 5° à 10° dans le chantier, suffisante pour la formation du film.

Cependant, le plus souvent, les sauvetages nous mettent en présence de pavements humides. Nous n'avons pas le temps de sécher. L'étude théorique systématique des résines de synthèse et leur expérimentation nous ont conduit à accorder le plus grand intérêt à la série des résines époxides. C'est grâce à ces dernières que nous avons pu entoiler et déposer des pavements mouillés que les circonstances ne nous permettaient pas de sécher, ainsi que des pavements fracturés, au support très dur, très épais et irrégulier. Cette courte étude ne saurait être ni un livre de recettes, ni un traité sur la technologie des résines époxides. Disons qu'il existe parmi ces résines plusieurs formules qui permettent l'adhérence sur des supports humides, qui catalysent en milieu humide, sous l'eau ainsi qu'à des températures inférieures à 10°. A plus forte raison ces résines sont utilisables sur mosaïques sèches et à température moyenne (15°, 20°). Nous les choisissons en fonction du "climat", du "milieu" au moment de l'application, de leur qualité d'adhésion, de leur souplesse ou de leur rigidité, et de la plus ou moins grande facilité à les enlever par la suite. Lorsqu'il est nécessaire de traiter des mosaïques restaurées antérieurement sur des dalles de ciment armé, ou des mosaïques antiques solidaires de supports très durs, fracturés et irréguliers, nous les entoilons aussi à l'aide de résines époxides parce qu'elles nous

permettent ensuite de scier le béton armé ou le béton de l'ancien support (1) à la scie au diamant ; cette opération ne peut se faire que sous l'eau. Aucun autre adhésif ne permettrait de la réaliser dans ces conditions.

Dans un système qui doit assurer la cohésion des tessères avant dépose, l'adhésif n'est qu'un des éléments, il faut aussi une armature. Cette dernière devra assurer la stabilité dimensionnelle du tapis de mosaïque, soit à deux dimensions, dans ce cas elle pourra être souple, soit dans les trois dimensions (cas de mosaïques à support très dur, ou à surface de révolution), dans ce cas elle devra posséder une certaine rigidité. Les armatures souples sont des toiles de coton désensimées à texture moyennement serrée, des tissus de verre ensimés à l'époxi-silane. Pour assurer une meilleure stabilité dimensionnelle, il est indispensable de doubler tous les entoilages autres que ceux réalisés à l'aide de résines époxides, par au moins une feuille de papier craft. Les armatures rigides les plus courantes sont constituées par des panneaux de "latté" de 15 à 25mm d'épaisseur ou par des sandwichs nids d'abeilles du type "Aéroweb".

Nous avons utilisé ce procédé par exemple pour une mosaïque mal restaurée en 1932 sur une dalle de béton de ciment de 34 cm d'épaisseur. Seuls des outils provoquant de fortes réactions mécaniques pouvaient être utilisés pour démolir ce béton. Il ne fallait pas que ces réactions provoquent des fractures auxquelles aucun système souple n'aurait résisté. Après avoir entoilé à l'aide d'une résine époxide souple, très adhérente, et une toile de coton, nous avons découpé le pavement, perpendiculairement à la surface, à la scie au diamant et à l'eau. Ensuite, avec un mortier époxide de consistance crémeuse assez rigide, nous avons scellé des panneaux de latté de 19mm d'épaisseur. Après catalyse, nous avons pu déposer en quelques heures 18m2 de mosaïque sans autre perte que les tessères détruites par les traits de scie. Toutes les personnes consultées au préalable avaient déclaré l'opération impossible.

Dans le cas de mosaïque sur voûte, abside voûtée, ou sur coupole, il est possible de dissocier la fonction cohésion des tessères dans une surface, de la fonction surface de révolution, c'est-à-dire surface d'un volume. La mosaïque est entoilée à l'aide d'un système souple sur lequel est moulé indépendamment un support en latex ou silicone avec une armature en nid d'abeille ou en mousse de polyuréthane. Le moule est démonté, remonté au sol et les éléments de mosaïque déposés sont assemblés en connexion à l'envers sur le moule. La restauration peut alors être effectuée en assurant à la mosaïque la stabilité dimensionnelle de sa surface et la position de sa surface dans l'espace.

Les circonstances administratives ou techniques ne permettent pas toujours de déposer un pavement en un seul élément. Si l'on est contraint à fragmenter le pavement, il faut accorder le plus grand soin à cette opération, respecter le décor, identifier, orienter et repé-

(1) Nous appelons "ancien support" tout ou partie de l'ensemble constitué par le bain de pose, le <u>nucleus</u>, le <u>rudus</u> et le <u>statumen</u> ; nous traduisons ces derniers termes par chape, forme, hérisson.

rer parfaitement tous les éléments. Les moyens les plus rapides de séparer les éléments, mais pas les meilleurs, sont le clivage et le sciage à la scie à pierre électrique ; si les matériaux sont très durs, nous utilisons la scie au diamant.
La désolidarisation de la mosaïque se fait à l'aide de lames d'acier de différentes longueurs munies de têtes de frappe et de tranchants au carbure rapportés. On peut les utiliser manuellement, à l'aide de marteaux électriques ou pneumatiques. Chaque fois que cela est possible, les lames de dépose sont introduites dans le plan de stratification situé entre la forme et la chape entre le rudus et le nucleus. Il ne faut jamais les introduire au-dessus, entre le tapis et le nucleus. En revanche, si la première solution n'est pas possible, il faut passer plus bas, c'est la sécurité avec en contrepartie un poids plus grand. Nous avons normalisé la dimension des éléments déposés à 1,00m × 1,50m, mais nous avons déposé aussi des éléments de 25m2 en un seul élément.
Nous n'utilisons pas le "rouleau" parce qu'on ne peut enrouler que ce qui est souple, le béton ne l'est pas. D'autre part, à l'expérience, nous avons noté bien d'autres inconvénients, l'encombrement, la remise à plat avec des grains de sable coincés entre les tessères qui font éclater le <u>tesselatum</u> . Nous pourrions citer des destructions célèbres "réussies" grâce au rouleau. Après avoir introduit les lames sous la mosaïque, nous glissons un panneau de contreplaqué sous les lames. Nous retirons panneau, lames et mosaïque. Nous enlevons les lames les unes après les autres. Nous posons sur la surface entoilée de la mosaïque un panneau identique à celui qui est dessous. Nous retournons l'ensemble. La mosaïque se trouve "à l'envers" sur un panneau où nous inscrivons les numéros du chantier de la mosaïque et de l'élément, ainsi que les orientations. Avant manutention, nous égalisons rapidement la face postérieure en enlevant les rognures du béton antique les plus importantes. Nous chargeons et nous calons les panneaux normalisés avec les éléments de mosaïques qu'ils supportent dans les containers S.N.C.F. plombés. Les bulldozers peuvent achever leur destruction.

Le sauvetage de la mosaïque n'est pas acquis pour autant. Souvent nous avons déposé des pavements humides, nous avons superposé des panneaux supportant des bétons antiques irréguliers. Il faut éviter que les panneaux de support provisoires ne s'altèrent, qu'ils ne moisissent ou qu'ils ne se déforment. Il faut sécher les pavements en atelier, désinfecter les panneaux, éliminer les vestiges de support antique, après avoir prélevé tous les échantillons nécessaires.
L'ablation de l'ancien support s'effectue à l'aide de scie au diamant grâce à laquelle on détermine un quadrillage de quelques centimètres de profondeur. Puis on fait sauter le béton au ciseau à main ou au ciseau électrique. Cette opération est renouvelée avec prudence autant de fois qu'il est nécessaire, jusqu'à l'approche de la face postérieure du <u>tessellatum</u>. Chaque fois que les contraintes mécaniques résultant de l'ablation du support risquent d'être supérieures à l'adhésion des tessères sur le système de support provisoire, il est nécessaire d'imprégner l'ensemble. Nous utilisons encore des résines époxides dont la fluidité doit être modifiée chaque fois en fonction du cas particulier. Elles sont catalysées sous infra-rouge. On achève l'ablation des derniers millimètres de l'ancien mortier à l'aide de ponceuses électriques. La surface est ensuite dépoussiérée à l'aide d'un

puissant aspirateur. Nous remplaçons l'ancien support par une première strate de mortier de résine époxide de 1 à 1,5 mm d'épaisseur armé de tissu de verre. Nous pouvons considérer qu'à ce stade les pavements sont en condition de conservation, c'est-à-dire qu'on pourrait les conserver 20 ans ou 100 ans sans dommage, même dans des conditions de température et d'humidité défavorables, en attendant de disposer des moyens nécessaires à leur restauration.

SAUVETAGE : CONSERVATION ET RESTAURATION

Nous avons noté les causes les plus certaines de destruction de plusieurs centaines de pavements de mosaïque découverts en Gaule depuis vingt deux ans. Les renseignements rapportés se réfèrent à des observations personnelles, sauf pour les destructions où sont réunis l'étude des publications, les renseignements recueillis dans la presse et nos propres observations.

Mosaïques usées par utilisation et restaurées dans l'Antiquités	5
Mosaïques surement usées par une ancienne utilisation	1
Mosaïques altérées par la superposition d'un autre revêtement	3
Mosaïques détruites par la destruction de la construction aucune à notre connaissance	
Mosaïques altérées à la destruction de la construction : par le feu	22
par la chute de coprs lourds	46
Mosaïques altérées par l'effondrement du soubassement après abandon des constructions	108
Mosaïques altérées par défaut de la liaison support-tapis	20
MOsaïques détruites à cause de leur découverte, plus de	3000
Mosaïques détruites à cause de leur restauration	8
Mosaïques altérées à cause de leur restauration	67
Mosaïques détruites ou partiellement détruites à cause de multiples transferts depuis leur découverte	22

Bien que ces chiffres n'aient qu'une valeur relative, on peut conclure que ce n'est pas la fin de l'Antiquité qui a été néfaste aux pavements de mosaïque, mais l'Archéologie et la restauration ...

Le but du sauvetage d'un document archéologique n'est pas la technique de la conservation en elle-même. C'est un acte philosophique,quasi religieux qui consiste à préserver un témoignage de l'art et de l'industrie de l'homme, témoignage qui sert de fondement à la connaissance. Le document sauvé ne trouve sa pleine signification que par sa restauration et sa présentation. Par restauration, nous entendons les opérations de désentoilage, de préparation à la restitution, transfert sur un support neuf, restitution des saignées et des petites lacunes, traitement de la surface, traitement des grandes lacunes. Toutes ces opérations mériteraient d'être décrites et discutées en détail, mais une seule est vraiment importante, c'est le choix du mode de transfert et du matériau utilisé comme support nouveau.
Les pavements de mosaïque antique ont été réalisés à l'origine sur des formes et des chapes en béton et en mortier de chaux. Si des causes extrinsèques n'étaient pas venues porter atteinte à ce support, nous aurions aujourd'hui des pavements quasi intacts. En théorie et

en pratique le mortier de chaux et de semoule de brique (1) est un excellent matériau pour supporter un revêtement de mosaïque. Si nous disposions aujourd'hui de la place nécessaire, d'un fondement sain, solide et imperméable, et si nous avions en même temps la certitude qu'une mosaïque restaurée sera présentée à demeure <u>ad vitam</u>, nous devrions la transférer sur un support en mortier de chaux identique au mortier d'origine. Or, les causes principales d'altération et de destruction des mosaïques restaurées en France entre 1818 et 1950 sont sans conteste, le transfert sur dalles de ciment ou de ciment armé et les transferts successifs.

Le ciment

1 - L'ancien support n'est pas toujours complètement enlevé. Le ciment aura une excellente adhérence sur la face arrière des tessères "propres". Les contraintes d'expansion et de retrait du ciment au cours de sa prise vont "cisailler" les tessères et les vestiges de l'ancien support oublié. Les tessères vont se désolidariser et disparaitre dans ces zones.

2 - L'ancien support est bien enlevé partout. Les contraintes dûes à la prise du ciment vont provoquer la courbure du nouveau support, nous sommes en présence de dalles convexes. Pour les "redresser", elles seront poncées, résultat après quelques années : destruction du pavement.

sur dalle béton — après ponçage — après 10 ans

3 - Si les dalles deviennent convexes, les joints entre les tessères vont s'élargir un tout petit peu, suffisamment pour que le mortier de rejointoiement antique se détache et puisse être enlevé par un simple brossage. Les restaurateurs ont donc effectué un rejointoiement au ciment pur.

4 - La prise du ciment libère des sels solubles provenant de l'hydratation des silicates, des phases aluminates et féritiques en présence de sulfate de chaux qui vont migrer à travers les capillaires des matériaux constitutifs des tessères, cristalliser en surface sous forme d'efflorescences grises insolubles.

5 - Pour enlever ce ciment gris-vert qui décidemment n'est pas beau, on l'a "nettoyé" à l'acide chlorydrique... Les sels insolubles ne seront pas éliminés pour autant. Inutile de dire que les mosaïques qui ont subi de tels traitements sont altérées à jamais.

6 - Dalles de béton armé soumises à des chocs thermiques ou mécaniques : la dilatation des aciers ou la transmission des contraintes par les aciers entraine la destruction du tapis de tessères. Comment déposer sans risque des mosaïques scellées sur 34 cm de béton ?

(1) Poudre de brique, brique concassée, tuileau ...

Nous avons été appelés à reprendre les anciennes collections des musées de Lyon, Bordeaux, Valence, Vienne, Périgueux, Colmar ...
Toutes ces mosaïques avaient subi plusieurs restaurations, avaient été transférées sur cire végétale, sur dalles de ciment ou de béton armé. Toutes celles qui n'ont pas été entièrement détruites sont sans exception irrémédiablement altérées . En conséquence, nous pensons que le transfert sur ciment est à proscrire absolument.
Et pourtant, nous avons effectué des transferts sur dalles en béton : nous avons utilisé du ciment fondu ; les dalles ont été vibrées, traitées et armées avec une double armature en treillis d'acier Tor soudé. Pour une surface de 16m2, elles n'avaient que 6cm d'épaisseur. Bien que ce soient des dalles ultra-minces en fonction de la technologie du béton armé, elles pesaient cependant 4 tonnes chacune...
Chaque manutention coûte le tiers du prix de la restauration, le risque d'accident demeure.

Les transferts

Vingt deux pavements qui avaient été sauvés, déposés, restaurés, ont été détruits en un siècle uniquement à cause de leurs transferts successifs ... Par exemple, la mosaïque d'Orphée découverte en 1822 à Sainte-Colombe, près de Vienne dans le département du Rhône. Elle mesurait 37m2 ; à sa découverte, elle était composée de 54 emblema octogonales. Après trois transferts et trois restaurations successives, il ne reste aujourd'hui que trois emblema représentant moins d'un mètre carré de surface ...
Que faire ? Le mortier de chaux et de brique pourrait être un support idéal, s'il n'y avait pas de risque de déplacement du document. Ne peut-on pas transformer un pavement en objet mobilier en le transférant sur un support qui ne présente pas les inconvénients du ciment ? C'est ce que nous avons essayé de faire. A partir de 1963, en Angleterre et en Allemagne, les résines époxides et des structures en nid d'abeilles sont expérimentées. Dès 1965 nous avons entrepris des essais systématiques d'utilisation des résines époxides et des structures légères à la conservation des peintures et des mosaïques.
Il existe aujourd'hui dans le commerce des sandwichs stratifiés qui présentent des caractéristiques mécaniques, physiques et chimiques remarquables pour un poids très faible. Ils sont composés d'une âme à structure en nid d'abeille d'aluminium entre deux feuils stratifiés de tissu de verre et de résines époxides. Une mosaïque, le tapis de la mosaïque, les tessères seules, pèsent en moyenne 20 Kg au mètre carré. Si nous transférons un mètre carré de mosaïque sur un mètre carré de sandwich léger, nous ajoutons seulement 4 Kg de support.

Nous utilisons depuis plus de huit ans ce type de support. Nous faisons fabriquer ces panneaux sandwich en Angleterre avec des caractéristiques et des normes qui correspondent à nos besoins. Les délais de livraison sont longs ; il faut en commander des quantités relativement importantes ; ils sont chers, mais ils résistent à l'humidité, au feu, aux micro-organismes. Ils sont faciles à utiliser. Ils sont mécaniquement réversibles. Mais surtout ils permettent de transformer une mosaïque, immeuble par destination, en un objet mobilier.
Il ne sera plus nécessaire de la déposer et de la détruire pour en changer l'affectation ou la dévolution.

L'utilisation de ces sandwichs ne constitue certes qu'une expérience ; ce n'est pas le seul type de transfert que nous mettons en oeuvre. Nous avons effectué des transferts sur des supports en béton de chaux, sur des planchers en béton armé avec une chape de matériau léger intermédiaire, etc... Les avantages et les inconvénients de ces essais ajoutés à l'expérience des autres techniciens permettront peut-être de définir par la suite, non pas des recettes, mais une méthode. Shématiquement, pour terminer, voici comment se poursuivent les opérations de restauration d'une mosaïque "type" (1).
Préparation des panneaux de support neufs à partir des sandwichs bruts normalisés : tracé, découpage, collage, formation des chants des panneaux, mise en place des pièces spéciales de fixation, d'assemblage et de manutention. Nettoyage des sandwichs pour éliminer les traces d'agents de démoulage aux silicones résultant de la fabrication. Le collage des panneaux s'effectue à l'aide de mastic époxide. Les éléments de mosaïque qui avaient reçu sur leur face arrière une première strate de mortier de résine époxide armé de tissu de verre sont désentoilés. On procède au détourage des bordures, à la préparation à a restitution, c'est-à-dire au nettoyage des "caries", des petites lacunes, des bordures et des saignées. Ces éléments sont présentés à l'endroit sur le support neuf sur lequel on a reporté au préalable le shéma constructif relevé avant dépose. Les éléments sont parfaitement mis en connexion avec une précision de ± 0,3 mm, dessinés sur le support enlevés et retournés. Un mortier époxide à consistance crémeuse est alors mis en place sur le support neuf et sur l'envers de chacun des éléments qui sont scellés sur le sandwich, bien entendu à l'endroit.

La précision de l'assemblage permet des restitutions de saignées invisibles pour une personne non avertir. La restitution est effectuée selon les principes généraux admis en la matière (2) uniquement les éléments géométriques sûrs, dans les petites lacunes et les saignées, à l'aide de matériaux identiques d'aspect au matériau d'origine. Nous y ajouterons un respect méticuleux de la technique originale : dimension, nature, aspect de la "taille" de l'arête, "matière" de la surface des tessères ; dimension, forme, nature et couleur des joints.

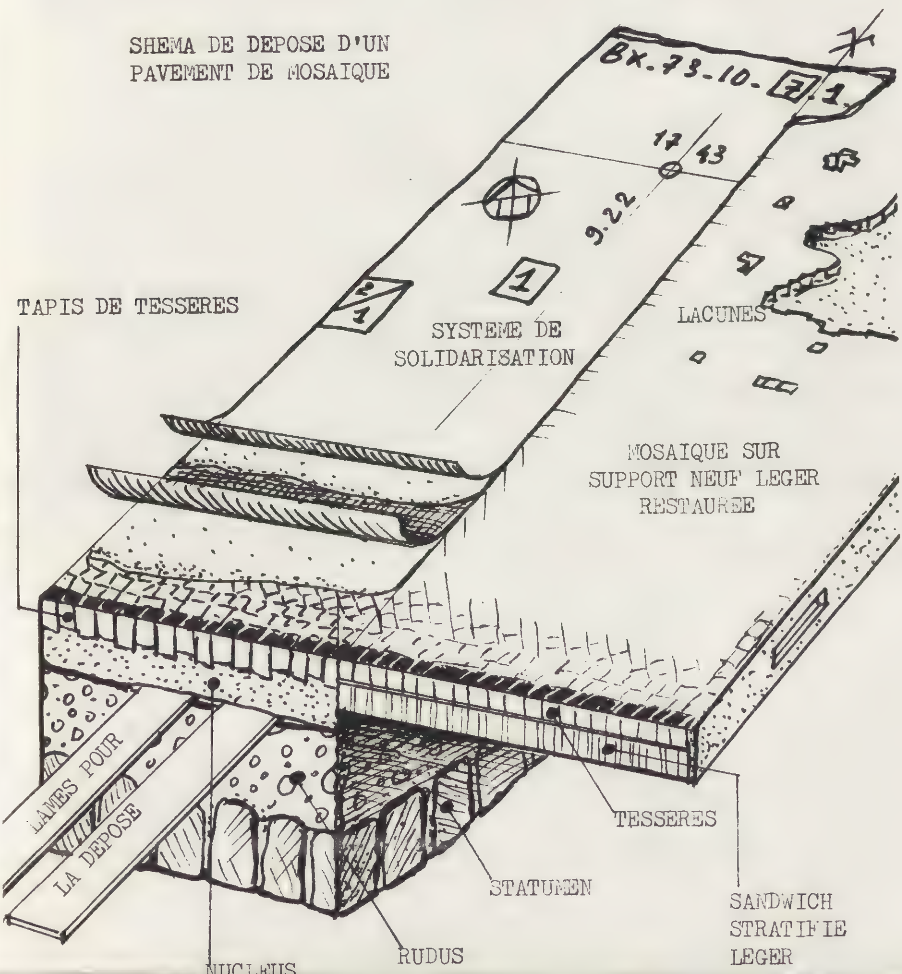
Le traitement de la surface du pavement est conditonné par les contraintes physiques et chimiques subies par la mosaïque qui en ont altéré la couleur et l'aspect. Il aura pour objet de stabiliser les phénomènes physico-chimiques évolutifs et de donner au pavement l'aspect le plus proche de celui qu'il avait à l'époque de son utilisation. Il faut éviter les ponçages destructeurs de l'épiderme ; cependant, un ponçage est souvent une opération thérapeutique nécessaire.

La mosaïque peut alors être présentée, mais cela est un autre problème. Avant de conclure, je voudrais réparer une omission importante. Les nécessités du sauvetage et de la conservation imposent certes une recherche technologique importante , mais aussi et surtout une

(1) dans la pratique, on ne rencontre jamais deux cas semblables
(2) Actes du IIe Colloque de l'A I E M A. Op. cit.

parfaite connaissance du document : analyse des matériaux, des techniques anciennes, des shémas constructifs, des unités de mesure utilisées et des structures. La dépose d'une mosaïque constitue une opération de fouille ; elle permet en outre la fouille des couches sous-jacentes. Cette étude constitue une véritable recherche archéologique; elle participe à la sauvegarde de la connaissance, parallèlement au sauvetage qui préserve le document. Cette analyse indispensable des mosaïques, lorsqu'elle sera systématique, constituera une aide non négligeable pour l'archéologie. Dans cet esprit, nous avons été conduit à établir un projet de fiche typologique des pavements de mosaïque que nous avons soumis à l'A I E M A. Nous souhaitons que cet exposé ait pu convaincre, si cela était nécessaire, qu'il ne faut jamais accepter la défaite, que ce soit devant les bulldozers ou devant la routine et que chaque étape n'est qu'une expérience parmi d'autres, que le temps jugera.

Claude BASSIER



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La méthode traditionnelle de dépose et de conservation des pavements de mosaïque antique est bien connue : elle est clairement expliquée dans : Isotta Fiorentini Roncuzzi, Arte e technologia del mosaïco, et dans Sanpaolesi Piero, La conservation et la restauration des monuments et des bâtiments historiques, Musées et Monuments XIV,P.196. Elle consiste essentiellement à entoiler le tapis de tessères pour éviter leur désolidarisation pendant la dépose et à transférer ces tessères sur un support neuf. Pour l'entoilage, c'est une forte colle animale qui est encore recommandée. Le transfert est en général ef ectué sur béton de ciment ou sur dalles de béton armé. Cette méthode a permis d'éviter la destruction de nombreux pavements de mosaïques ; cependant, elle présente des limites, des inconvénients et des contre-indications absolues. L'expérience acquise depuis vingt ans dans le sauvetage des pavements de mosaïque nous permet de proposer aujourd'hui de nouvelles méthodes pour leur dépose, leur conservation et leur restauration.

Traditional method for detaching and conservation of ancient mosaïc pavements is known. It is clearly explained in : Isotta Fiorentini Roncuzzi, Arte e technologia del mosaïco, and in Sanpaolesi Piero, La conservation et la restauration des monuments et des bâtiments historiques, Musées et Monuments XIV, P. 196. It consists specially to cover the <u>tesselatum</u> for avoiding their disassociation during the detaching and to transfer these <u>tesserula</u> on a new support. For the stiffening, an animal glue is recommended. The transfer is generally done on concrete of ciment or on flags of reinforced concrete. This method allowed to avoid the destruction of numerous pavements of mosaïc ; therefore, it presents limits, inconvenients and absolutes contra-indicates. The obtained experience for twenty years in the rescue of mosaïc pavement allowed us to propose to-day news methods for their detach, their conservation and their restauration.

NEW POSSIBILITIES OF POLYBUTYL METHACRYLATE AS A CONSOLIDATING AGENT FOR GLUE PAINTING ON LOESS PLASTER

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Abstract

Poly-n-butyl methacrylate of low viscosity grade "for restoration" of the USSR production (PBMA) proved to be reversible over 25 years and stable to UV-irradiation. New possibilities in the PBMA conservation technique for murals on loess plaster were revealed when using mixtures of "good" and "bad" solvents for PBMA instead of "good" solvents only. Thus impregnation by 10% PBMA solution in xylene-ethyl alcohol mixture in comparison with xylene solution of the same concentration gives more regular resin distribution inside porous material and considerably lesser changes in surface optical properties. Acetone-white spirit and some other solvent mixtures are efficient in cleaning processes and restoring the appearance of murals which were conserved in the field with excess of PBMA.

It is for more than 25 years that low vescosity grade poly-n-butyl methacrylate (PBMA) has been used

for restoration in the State Hermitage Museum. By applying PBMA, P.I.Kostrov and his co-workers solved the problem of removal from walls and conservation of paintings, executed in glue paints on loess plaster, and painted loess sculpture from archaeological discoveries in Middle Asia (I - 3). PBMA came to be applied also for conservation and restoration of frescoes, glue and emulsion tempera paintings on different porous supports, encaustics on wood and limestone, articles made of limestone,ceramics, wood, metal, glass and others (4).

The preference given to PBMA over other polymers in our museum and in some other restoration laboratories is due to its qualities. We use PBMA of a special grade "for restoration" produced in the USSR (the specific viscosity of I% solution in toluene 0,2 - 0,5). This thermoplastic, amorphouspolymer, being colourless, transparent, chemically inert and stable to light, is able to be dissolved in organic solvents of different classes (aromatic and chlorinated hydrocarbons, esters and ketones), producing solvents of wide-range technological possibilities. One of the main merits of PBMA is its low molecular weight. That's why its solutions in many organic solvents are able to penetrate deeply into weak mate-

rials of porous structure and provide their consolidation. Such consolidation is reversible, that is, in the process of restoration work the polymer may be repeatedly dissolved and, if necessary, almost completely removed from the material of the article. Our experience shows that the reversibility of PBMA is preserved with time. So, in 25 years after conservation had been carried out, PBMA remained soluble both in paintings placed in expositions and repositories and in murals consolidated (but not removed from walls) and again covered with earth.

The stability of poly-n-butyl methacrylate to aging is due to its chemical nature. According to the data of A.Ya.Drinberg et al. (5) the poly-n-butyl methacrylate films do not show any signs of cross-linking in the process of heating at I00-I40°C. Our experiments have shown that ultre-violet irradiation of mercury high-pressure lamps for 500 hours does not change PBMA solubility and its molecular weight.

PBMA possesses good adhesive properties and high relaxation capacity. Even in the cases when only a superficial layer of weak porous material is impregnated with PBMA no stripping off of the fixed layer occurs in the course of time under usual conditions.

In restoring paintings much importance is

attached to the preservation of their colours and texture. According to the technique of field conservation and removing paintings on loess support elaborated and applied in the State Hermitage Museum (I-3), a great quantitiy of PBMA is intoduced to consolidate the weak loess plaster and the paint layer, and to get a protective film on the surface as well. This results in a temporary change of the appearance of the paintings. Later on, in the course of the laboratory treatment the excess of the polymer is removed, the cleaning of the paint layer is undertaken, the texture of the glue-medium painting restored. More often than not, the condition and the state of preservation of archaeological murals, with their paint layer injured and the binding material lost, makes it necessary to reveal the pattern and colour on badly preserved sections. This can be achieved with the help of PBMA, by controlling its amount in the paint layer.

The PBMA technique was not, however, feasible in case when ultramarine was put over black paint or mixed with black pigment. To fix coarse-grained pigments, such as natural ultramarine, smalt, frit, a greater amount of binding material, than is necessary in other cases, has to be introduced. As a re-

sult, the transparency of the paint layer of the pigments mentioned is enhanced, and the underlying black layer becomes more active in colour, causing the darkening of the painting. Optical alterations of the paint layer resulted from introduction of a considerable amount of the binding material are more conspicuous on ultramarine and smalt, as their refractive index is lower in comparison with that of other pigments.

The problem was to find some means to conserve such paintings, their colouring preserved. Our experience of many years in working with PBMA gave ground to suppose that the problem could be solved by applying the same consolidating agent.

We proceeded from the following general considerations: The processes of impregnation porous materials with polymer solutions and the final result of treatment (such as the depth of the solution penetration, distribution of resin in the material, the produced strength of the material) are determined by such factors:

a) the character of the capillary-porous structure and the chemical composition of the material treated;

b) the solvent properties and the concentration

of the polymer solutions;

c) the technique and conditions of impregnation and drying.

As the consolidating agent (PBMA) remained the same, we varied the composition of the solvents, the concentration of solutions, the impregnation and drying conditions (6).

According to the technique employed previously the PBMA solutions were used in separate "good" solvents (xylene, acetone, methylethyl ketone etc. In such cases pulling up of the resin to the surface layer takes place during drying. Restrained drying delays the drawing of the resin, but all the same,a considerable part of PBMA concentrates in the surface layer, which causes the change of its optical properties. The data found in literature on the influence of the chemical nature of solvents upon the structure and properties of films formed from polymer solutions (7) suggested the following: by choosing combinations of solvents (their polarity, volatility and dissolving capacity taken into account) it is possible to achieve such distribution of PBMA inside both the loess plaster and the paint layer when satisvactory consolidation is not accompanied by a substantial change of the surface optical properties.

The experiments carried out on some specimens of loess plaster showed that we were right in our assumption. The desirable consolidation almost without any alterations of the surface appearance may be achieved when PBMA is used in xylene-ethyl alcohol, xylene-butyl alcohol, xylene-ethyl and butyl alcohols mixtures or in mixture of white spirit and acetone, under a definite impregnation and drying regime. The best results were obtained when using the 10% PBMA solutions in the mixture of xylene and ethyl alcohol in the volume ratio 1:1. It was also found that by applying PBMA solutions of low concentration in alcohol-acetone-petroleum ether (1:2:1) it is possible to achieve an additional fixing of the paint layer, and to glue up its exfoliated parts without causing any colour changes.

Using PBMA solutions in given solvent mixtures, the pulling up of the resin during drying appears to take place in a considerably lesser degree. A more regular distribution of the polimer inside the plaster and the paint layer results, due to which the surface optical properties are preserved.

Of particular interest is the revealed possibility to restore the colouring of the paintings treated in the field with a great amount of resin without

removing the excess of it from the plaster.* This is achieved by putting the mixture of white spirit and acetone or the mixture of acetone, ethyl alcohol and petroleum ether on the painting surface. The process of cleaning the paint layer from dirt can be facilitated and speeded up by applying for a short time compresses wetted in the mixture of white spirit and acetone.

It is to be noticed that alcohols and aliphatic hydrocarbons are not poly-n-butyl methacrylate solvents. PBMA, however, swells in alcohols and may be dissolved in white spirit if it contains a sufficient quantity of aromatic compounds**. White spirit used in our experiments did not dissolve PBMA completely but caused its swelling.

It is known that the polymer solution viscosity in "bad" solvents rises with the concentration increase more sharply than the solution viscosity in "good" solvents. This is due to the peculiarities of

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* Under the colouring of the paintings we mean here their appearance when discovered in archaeological excavations.

** According to the USSR state specification (GOST 3134-52) white spirit or benzine-solvent for paint and varnish industry may contain as much as 16% of aromatic hydrocarbons.

the molecular polymer interaction with solvents of different chemical nature (7). We difined viscosity of PBMA solutions in acetone, xylene and in xylene-ethyl alcohol and acetone-white spirit mixtures (volume ratio I:I). The data obtained are shown in Table I. They give ground to consider the xylene - ethyl alcohol and acetone-white spirit mixtures to be the best PBMA solvents in comparison with the good solvents - xylene and acetone.

Table I. The specific viscosity of PBMA solutions in different solvents (Ostwald viscosimeter, the capillar diameter 0,6 mm)

PBMA concentration (%)	Solvents			
	acetone	xylene	xylene-ethyl alcohol (I:I)	acetone-white spirit (I:I)
I	0,45	0,32	0,33	0,23
3	0,98	I,I4	0,92	0,93
5	2,23	2,I5	I,84	I,90
7,5	4,8I	4,08	3,0I	3,05
I0	7,77	6,26	6,03	5,22
I5	2I,36	I4,00	II,5I	II,I5

The work will be continued in search of the best solutions of practical tasks and towards the elaboration of theoretical problems of consolidation paintings on porous support with polymer solutions in various combinations of organic solvents.

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THE RESTORATION OF MONUMENTAL PAINTING FROM MEDIEVAL SHAKHRISTAN

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Abstract

The restoration of murals discovered during archaeological excavations in Tadzhikistan in 1967-1972 is described. A new technique of detaching murals from the walls was used. For the first time ftorlon Ф-42Л was applied for the restoration of murals.

This report deals with the restoration of mural painting excavated from the hill Kalai Kakhkakha palace in the north of Tadzhikistan, near the little town of Shakhristan in 1967-1972. The excavations were carried out by the Tadzhik SSR Academy of Sciences Institute of History with the participation of the workers of the State Hermitage restoration studio. Due to the abundance of painting found (all in all about 30 m^2), good condition of many fragments,

originality of plots (for example the picture of mother-wolf feeding two infants) these findings are to be attributed to some of the most significant ones on the Middle Asia territory for the last years.

Shakhristan mural paintings were executed at the turn of VIII-IX centuries A.D. They are chronologically final following the painting of Toprak-Kala, Balalyk-Tepe, Varakhsha, Afrasiab and Pendzhikent already known. Shakhristan murals are thus the last known example of the Middle Asia monumental art of premoslem period.

Support of the murals is loess plaster having two layers. The upper layer consists of pure loess, very dense, not more than 5 mm thick, the surface is flattened, almost polished. The lower plaster layer, I,5 to 2 cm thick, had a great admixture of chopped straw, burned and decayed. The ground of the murals is white, made of gypsum and chalk.

Microchemical and spectral analyses showed that the Shakhristan murals were executed in ultramarine, yellow and red ochre, charcoal black, gypsum with chalk, massicot and a green coppercontaining pigment - malachite or chrysocolla.

At the close of the IX century the palace was destroyed and burned down by the Arab conquerors.

During the fire most of the murals crashed down from the walls and being broken into little pieces were covered with burnt up wooden parts, wreckage of the clay walls and a thick layer of loess dust. The paintings on the walls were preserved at the height of not more than I,5 metres. They were scorched all over, damaged with cracks, small and big dents. The paint layer was badly preserved, the ground was almost indistinct, most of the designs were hardly visible.

As a rule the paint layer on the fragments found in the debris preserved much better. Many of these fragments are of great interest not only for their plots but for their colouring as well. The plaster of the fragments from the debris became as strong as ceramics. The glue binding of the painting was destroyed, both the paint layer and the ground required consolidation.

The treatment of the Shakhristan murals found on the walls was carried out mainly by applying polybutyl methacrylate (PBMA) for consolidation. Tis method was worked out in the State Hermitage Museum at the end of the 40s for glue painting on loess plaster. In field conditions, before the murals were taken off the walls, eight impregnations of face side of the painting with 20% PBMA xylene solution proved

sufficient for conservation. The fact that the painted plaster was on very solid clay walls did not permit the painting to be detached by applying the usual method of cutting out the wall. A new technique was therefore used - the technique of pressing the mural to a flexible plywood board in the process of cutting the painting from the wall. In using this method it is indispensable to reduce the time necessary for the plaster to dry after impregnation. The paintings were dried to such an extent that the plaster became mechanically strong, but some part of the solvent still remained in them so that it prevented the plaster from breaking when bent a little. The operation of the painting removal was carried out as follows. First the painting fixed with PBMA was cut on some fragments and glued with a layer of gauze by applying 5% polyvinyl butyral alcohol solution. Then a plywood board with horizontally nailed laths was closely placed to the fragment to be detached and the gauze hems were fastened to the edges of the board. After this, using long knives, the murals were cut from the wall, the plywood being gradually turned back. The greatest size of the fragments detached in this way was I,5 x I m.

In the State Hermitage monumental painting

restoration studio the detached murals underwent furher treatment. They were additionally impregnated with PBMA xylene solution and after drying they were desalted by soaking in distilled water, which was periodically changed. The maximum content of chloride-ions in the murals taken off the walls was 0,75%. To remove them, not more than 2 days with 2-3 changes of water were required. Then the fragments were taken out of the water, put face down on a few sheets of filter paper and covered with a thin layer of river sand to slow down the drying. Besides, the sand allowes the painting to avoid cleavages and deformation. The cleaning of the painting was carried out with a scalpel, by applying some solvents. Acetone, methyl ethyl ketone, white spirit, carbon tetrachloride and their mixtures were used depending on their effectiveness. Bringing these badly damaged murals to a state when they could be exhibited presented a complex problem. To reveal the design, the most obliterated areas of the painting and the outlines were additionally impregnated in one or another degree with PBMA solutions.

Quite another method was employed for the conservation of fragments found in the debris with their painting layer in a good state. In 1970 when a great

number of such fragments was discovered for the first time we tried to use PBMA solutions for the consolidation, but this caused conspicuous changes in colouring. To avoid them by reducing the amount of PBMA introduced into the painting proved a failure.

The dominant colours of the Shakhristan paintings - the blue and the light blue - darkened most heavily. In our opinion, this is to be accounted for, in the first place, by the fact that ultramarine, gypsum, chalk contained in the paint layer and the ground have the lowest of all pigments refractive indexes (I,50; I,52 and I,60 respectively), being very close to the refractive index of PBMA, which is I,485. That's why, according to Frenel's formula * these pigments more than the others become transparent in the PBMA medium, due to which the dark layer of the loess support shows particularly well.

The darkening of Shakhristan ultramarine is also caused by the specific features of the structure and composition of used pigment. The microscopic

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* $R = \frac{(n_I - n_0)^2}{(n_I + n_o)^2}$ Where R is the reflection factor on the division line of two media with refractive indexes n_I and n_o.

study showed that the ultramarine of most murals contained only a little amount of blue-violet crystals. It is the tiny pale blue particles, which after the PBMA treatment completely lose their colouration vague enough as it is that predominate.

We carried out some experiments to find some other polymers for the consolidation of the paint layer and the ground without causing any alteration to the colouring. About 30 various polymers and copolymers - acrylate, methacrylate, vinyl, polyamide, silicon and fluorocarbon kinds - were tried as fixatives. Among the substances tested were both new products suggested by chemical institutes and those already applied for the treatment of works of art. The latter include copolymers of butyl methacrylate with the methacrylic acid (БМК-5), of vinyl acetate with 2-ethyl-hexyl acrylate, of vinyl acetate with ethylene, silicon resin (K-I5/3) and fluorocarbons (Ф-42Л, H-6, Ф-26 and Ф-32Л). The solution or dispersion concentrations, solvents (when possible), the impregnation and drying regimes were tried out in many variations for each polymer. After this the strength of the paint layer consolidation and the change of its colour intensity were determined.

The best results were obtained when applying

fluorocarbon (ftorlon) Ф-42Л (we had two samples of Ф-42Л, the relative viscosity of their I% acetone solutions is 2,48 and 2,64). This fluorocontaining polymer and closely related to it ftorlons of other trademarks are used in the restoration of paper, metal, illuminated parchment, gouache, water colour, pastels, modern tempera. As other ftorlons, Ф-42Л is extremely resistant to various destructive factors.

Ftorlon is a polymer with a great molecular weight, high degree of crystallinity (up to 44%) and a low refractive index (I,36 - I,37). It is due to the combination of these properties that the colouring and the painting texture practically do not alter after treatment with ftorlon.

By the following excavation season I97I there had been worked out a new restoration technique which embraced all the stages of restoration the painting passes through - from excavation to the museum exposition. Extracted from the debris, the fragments were received a preliminary cleaning and then were placed into a tent. The face part of the painting was covered from 7 to IO times with 3% ftorlon solution in mixture with ethyl acetate and butyl acetate. The impregnation was carried out with a brush in 2-3

steps with 5 minutes interval. Then the murals were covered with a flat box wrapped up in a polyethelene film served as a lid. This technique made it possible to avoid the formation of the surface film and enabled ftorlon to permeate through all the paint layer and the ground up to the solid plaster surface. In cases when even after impregnation with 3% solution the paint fell off the plaster and flaked, a 5% solution was introduced under the blisters and the flakes. This operation was carried out with a brush, sometimes up to 3-4 times, the flakes being pressed to the painting with a scalpel. As a result of ftorlon impregnation the pigment particles become tied with those of the ground, a firm attachment to the plaster following.

Since the back side of the plaster is more porous and crumbly in comparison with the very solid and dense face side the reverse side of the mural painting was 5-7 times covered with 25-30% PBMA xylene solution, which ensured consolidation to the depth of 3-5 mm. The borders of every fragment were fixed 2-3 times with 7-10% PBMA acetone solution. Some fragments were glued together by applying PBMA acetone solution to form larger fragments. The experimental specimens, treated by this method, showed good

resistance properties against sharp artificial fluctuations of temperature and humidity.

In the studio the removal of salts from the paintings fixed with ftorlon was carried out by soaking. After complete drying the fragments were glued to reconstitute the composition, as far as it was possible, and then mounted either on foam polystyrene slabs, or applying polyurethane resin ППУ-305 foamed in situ. The final stage of the work in the studio is to bring the painting to the exposition state. Since Ф-42Л is fully reversible, the removal of ftorlon from the surface and the cleaning do not offer any particular difficulties. The cleaning is carried out with a scalpel by applying acetone or methyl ethyl ketone. Even when there is a great number of losses, the paintings, as well as the fragments detached from the walls, did not undergo any reconstitutional retouchings. The losses and cracks were filled with loess putty on ftorlon.

During the Shakhristan excavations in I97I-72 all in all more than I5 m^2 paintings were collected from the debris and consolidated by applying ftorlon. A part of them has been restored or is being restored in the State Hermitage Museum.

MÉTHODES DE DÉTACHEMENT DES MORTIERS DES PEINTURES À FRESQUE SUPERPOSÉES DES XII^{e}-XVII^{e} SIÈCLES ET DE TRANSPOSITION D'UN MORTIER DU XVII^{e} SIÈCLE SUR UN NOUVEAU SUPPORT DANS L'ÉGLISE DU SAUVEUR DE BÉRÉSTOVO DU PARC DE RÉSERVES D'ÉTAT HISTORICO-CULTUREL DE KIEVO-PETCHORSKI

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Les chercheurs considèrent que la construction du temple du Sauveur de Béréstovo à Kiev était liée aux activités du grand-duc russe ancien Vladimir Monomakh et situent sa date à la limite des XI^{e}-XII^{e} siècles.

Le temple du Sauveur - c'est un grand bâtiment à trois nefs et six piliers. En 1240, pendant l'intrusion des Tataro-Mongols il avait été détruit. Seule sa partie antérieure ouest, couverte de voûte, au-dessus de laquelle se trouvait le choeur, s'est conservée. L'hauteur de la voûte au niveau du sol moderne qui est egale à 10 m. nous permet d'imaginer toute la grandeur du temple (remarquons à titre de comparaison que l'hauteur des voûtes de la cathédrale de Sophie à Kiev - 7,5 m, de la cathédrale du Sauveur de Tchernigov - 7,0 m).[1)]

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1) Г.Логвин, "Возрождение фрески ХII в.", "Искусство" № 8, I97I, стр. 64. (G.Logvine, "Régénération d'une fresque du XII^{e} siècle", "Iskousstvo", N° 8, 1971, p. 64).

Le temple de Bérestovo avait été une sépulture des Monomakhs, où, d'après les chroniques, en 1157 avait été enterré le fils de Vladimir Monomakh - Youri Vladimirovitch Dolgorouki, le fondateur de Moscou.

Au milieu du XVII^{e} siècle le temple a été reconstruit en utilisant des parties anciennes conservées. À l'initiative du métropolite Pierre Moguila l'intérieur a été orné de fresques (peintes par un maître d'Aphone) qui ultérieurement renouvelaient à plusieurs reprises.

Les travaux de restauration de l'église, effectués en 1906-1914 et puis, à l'époque soviétique, en 1935, n'ont pas réussi à donner la réponse à la question de présence de fresques du temple ancien du XII^{e} siècle. En effet, on n'en a trouvé qu'un seul fragment, sous le toit de l'église, qui représentait un ange à une sphère. Les recherches des peintures murales anciennes entrepris dans d'autres endroits du temple sont restés sans résultats. Les savants en ont conclu que les fresques du XII^{e} siècle dans ce temple ne se sont pas conservées, sauf un fragment susmentionné.

Au mois de mai 1970 les peintres-restaurateurs de l'atelier de restauration de Kiev ont aperçu, sur le mur ouest du narthex ancien du temple, le détachement du mortier avec des peintures à fresque du XVII^{e} siècle. Il a été décidé de fixer les parties détachées du mortier par injection.

En perçant les perforations pour y injecter un fixatif, on a remarqué une couche de peinture qui se trouvait sous une couche du mortier.

Les sondages détaillés réalisés selon une motion du Conseil de savants de la Construction d'Etat de l'USSR, ont donné des résultats frappants: sous le mortier du XVII^{e} siècle on a découvert des fresques

du XII^{e} siècle, étendues sur une surface de 80 m^{2} environ.

Une méthode de détachement du mortier portant des fresques des XII^{e} et XVII^{e} siècles et de transposition du mortier du XVII^{e} siècle sur un nouveau support a été élaboré donc par les restaurateurs de l'atelier de Kiev en collaboration avec les chercheurs du Laboratoire de la Direction spéciale de recherche de production et les restaurateurs du VCNILKR.

Cette méthode comprend les opérations suivantes:

1. Elimination des encrassements superficiels.

La fresque du XVII^{e} siècle à détacher du mur fut soigneusement nettoyé de la couche superficielle de saleté. Nettoyage fut mené à l'aide d'un tampon de coton imbibé d'une solution eau-alcool (1:1).

2. Collage du papier mikalentnaïa et de la gaze muni d'une carcasse sur une fresque à déposer.

Sur une fresque nettoyée d'une couche superficielle de saleté on a collé du papier mikalentnaïa et de la gaze muni d'une carcasse. Le collage s'est fait à l'aide de la colle d'esturgeon à 10%. On appliquait la colle sur la surface de la peinture à l'aide d'un pinceau à poils doux, puis on a mis du-dessus le papier mikalentnaïa, en le serrant contre la surface picturale par une brosse. Au-dessus de papier on a mis deux couches de gaze.

Une fois le fragment de peinture à ôter séché (partiellement), on a collé sur lui une carcasse, à la colle esturgeon à 10%, pour faciliter sa dépose du mur et éviter des déformations éventuelles. Cette carcasse est faite des lattes de bois, ayant une section

25x25 mm. Les lattes ont été collées à l'aide des bandes de gaze mises à la distance de 10 à 15 cm l'une de l'autre. Les lattes était fixées l'une à l'autre au moyen des vis à bois.

3. Marquage et sciage des parties d'une fresque.

Les lignes de coupage ont été tracées par un crayon sur la gaze de manière que les visages, mains et pieds peints ne soient pas touchés. Sur les lignes de marquage on a fait des signes, qui devraient coïncider l'un à l'autre lors du remontage des fragments sur nouveau support.

La fresque a été sciée au moyen d'une scie chirurgicale, avec grand soin, suivant des lignes tracées par crayon, en profondeur du mortier jusqu'à 10 mm. A cette profondeur on faisait une pression par la scie perpendiculairement à la surface du mur. Au cours du sciage on nettoyait la coupe par soufflage à l'aide d'une poire de caoutchouc. Afin de faciliter l'opération de détachement et de dépose du fragment de la fresque, on faisait un sciage conique au-dedans de l'épaisser du mortier. Dans des endroits des joints les coins ont été coupés au moyen d'un scalpel.

4. Dépose du mur de la fresque du XVII^{e} siècle.

Le sciage du fragment de peinture terminé, on l'a détacheé d'une couche sous-jacente du mortier du XII^{e} siècle à l'aide d'une barre métallique inflexible, mise dans la coupe. Après cela on a déposé le fragment, en écartant du mur un des ces bords.

5. <u>Fixation des coupes de la couche du mortier du XVII^e siècle</u>

Les bords des fragment détachés ainsi que ceux des coupes sur le mur ont été dépoussiérés par soufflage et puis fixés par une solution de polyméthacrylate de butyle dans l'acéton à 20%.

6. <u>Fixation des creux (incisions) sur le mortier du XII^e siècle</u>

Les creux (incisions) sur la fresque du XII^e siècle ont été fixés par une solution de polyméthacrylate de butyle dans le xylol à 20% par imprégnation.

7. <u>Fixation du mortier du XII^e siècle par injection, en utilisant une presse et des goujons en bois</u>

Pour consolider le mortier du XII^e siècle on opérait comme suit: dans les perforations de 8 à 10 mm de diamètre et de 8 à 10 cm de profondeur, à l'aide d'une pompe, on introduisait une solution de résine de polyvinylchlorure dans le dichloréthane à 60% additionnée de brique finement broyée et de marbre comme matière de charge. La proportion de la brique et du marbre - 2 : 1.

Dans quelques heures on mettait des goujons en chêne dans cettes perforations et on les clouait de façon qu'ils soient un peu plus bas du niveau de la surface de la peinture. Avant d'introduire des goujons dans des perforations, ils ont été traités par une matière hydrofuge. On tâchait de percer des perforations dans les endroits des incisions.

8. <u>Fixation du mortier des fresques du XII^e siècle par méthode d'intégration</u>

Les parties manquants du mortier de fresque du XII^e siècle ont été comblées par un mélange de ciment, après avoir fixés au préalable ses bords au moyen d'une solution de polyméthacrylate de butyle dans l'acéton à 10-15%. Le mélange de ciment est composé d'une partie de brique morcelée, d'une partie de poudre de marbre et d'une partie de sable. Les lacunes bouchées ont été mastiqués et couvertes d'un ton neutre.

9. <u>Fixation et bouchage des fissures sur les fresques du XII^e siècle</u>

Les fissures sur le mortier ancien ont été bouchées par un mastic composé d'une solution de polyméthacrylate de butyle dans l'acéton à 15% additionée de craie comme matière de charge.

Préalablement cettes fissures ont été dépoussierées et imprégnées par une solution de polyméthacrylate de butyle dans l'acéton à 15%.

10. <u>Enlèvement d'un badigeon à la chaux des fresques du XII^e siècle</u>

Les deux couches de badigeon à la chaux qui se trouvaient entre le mortier de peinture du XVII^e siècle et la surface des fresques du XII^e siècle furent enlevées mécaniquement au moyen d'un scalpel. Certaines zones du badigeon, difficiles à enlever, furent éliminées à l'aide des dissolvants.

Le lavage des fresques s'est fait par une solution de polyacrylamide à 0,1%. On appliquait la solution à la surface de la peinture par une brosse douce et puis l'enlevait avec un tampon de coton.

Simultanément à une élimination des encrassements on enlevait des restes du badigeon de chaux.

11. Préparation de la fresque ôtée du XVII^{e} siècle et sa transposition sur un nouveau support

Le badigeon de chaux ainsi q'un mortier en excédent du revers des fragments de fresque déposés ont été enlevés. Le mortier du XVII^{e} siècle se compose de deux parties: d'une couche inférieure, "arriccio", contenant beaucoup de paille, et d'épaisseur de 7 cm et plus, et d'une couche supérieure, plus mince, "intonaco", d'épaisseur de 1 à 2 cm. Une épaisseur aussi grande de la couche inférieure s'explique par le fait qu'on l'avait utilisé pour combler des lacunes du mortier du XII^{e} siècle. Nous avons été obligé de couper entiérement une couche inférieure du mortier pour arriver jusqu'à première couche, qui a été puis imprégnée d'une solution de polyméthacrylate de butyle très visqueux dans l'acéton à 18-20%.

Après l'imprégnation une tissu de verre a été collée par une solution de polyméthacrylate de butyle très visqueux à 20% et serée au moyen des presses jusqu'au séchage. Les fragments de fresque traités de cette manière ont été remontés sur des châssis de bois, en comptant le dessin de la composition, à l'aide de même solution, additionnée de craie jusqu'à une consistance de la crème fraîche.

Dix compositions ont été remonté de cette façon: parmi elles - six compositions à un personnage et quatre - à plusieurs personnages. Dans la partie inférieure du mur quelques compositions furent déposées d'un seul tenant, sans les scier sur les morceaux. Dans les autres cas on opérait d'une façon différen-

te; les zones où il y avait des lacunes du mortier et du maçonnerie du XII^e siècle étaient surtout difficiles à détacher.

12. <u>Enlèvement des carcasses, de la gaze et du papièr mikalentnaïa des fresques du XVII^{e}siècle</u>

Après avoir remonté des compositions des fragments déposés du mur, on a procédé à une élimination des carcasses, de la gaze et du papier mikalentnaïa.

On a coupé la gaze, on a dévissé les vis à bois; puis on a mouillé la gaze et le papier mikalentnaïa collés sur la peinture à l'eau chaude jusqu'au moment de décollage d'adhésif, et l'on a éliminé tout ça. Dans les cas où la couche picturale faible se détachait avec facing, on appliquait sur cet endroit, pendant l'enlèvement du papier mikalentnaïa, une solution de polyméthacrylate de butyle dans l'acéton à 18-20%, et une couche picturale se trouvait remise sur sa place.

13. <u>Le nettoyage des fresques du XII^e siècle des surpeints postérieurs a été effectué à l'aide des dissolvants organiques en employant des compresses</u>.

14. <u>Bouchage des fentes entre fragments coupés et de petites lacunes sur la surface des fresques du XVII^e siècle</u>.

L'enlèvement des surpeints postérieurs fini, on a bouché les petits creux et les joints de sciage des compositions montées à neuf. Pour cette opération on a employé une solution de polyméthacrylate de butyle dans l'acéton à 15-18%, additionnée de craie comme matière de charge.

15. Fixation de la couche picturale des fresques du XVII^{e} siècle.

Il n'y avait pas besoin d'une opération de fixation de la couche picturale des fresques du XVII^{e} siècle, puisque cette fixation s'est produit déjà lors d'un collage du papier mikalentnaïa sur la surface de fresque.

Suivant cette méthode donc les restaurateurs de l'atelier de Kiev ont réussi à diviser en deux parties et à transposer à un nouveau support des fresques du XVII^{e} siècle, d'une surface totale de 19,4 m^{2}. Grâce à ce travail une composition unicale des fresques du XII^{e} siècle a été dégagée; elle se situe sur le mur ouest du temple, entre les deux fenêtres.

Dans la partie droite de cette composition nous voyons le Christ debout et sur une lagune, bordée de la côte - une barque à quatre pêcheurs traînant un filet. C'est une sène donc représentant "Le Christ sur la mer de Tiveriad~~sko~~e".

L'absence de composition représentant "le Jugement dernier" dans la partie antérieure du temple, d'après l'avis de G.N.Logvine, suggère une idée que ce n'était pas une tendance d'intimider ou de rappeller du châtiment qui était la principale, mais une demande de protection et de grâce.

Le maître avait parfaitement composé la scène, en travaillait librement sans avoir fait au préalable un dessin préparatoire, qui n'existe que sur le nimbe du Christ.

Le coloris des fresques est riche en teintes d'ocre-grise-bleue avec des incrustations des tons verts

émeraudes du sol et des silhouettes des pêcheurs de couleurs blanches dorées. Les problèmes de formes et de coloris de la composition sont resolus par des moyens très simples et dans une manière libre et hardie.

Etant donné que les fresques n'étaient pas repeintes à l'huile, nous pouvons voir des nuances les plus fines de la peinture ancienne. En ce qui concerne de la pulvérulence des pigments dans certains endroits, elle est si insignifiante, qu'il n'était pas nécessaire de fixer la surface picturale dégagée, qui se présente un quart des fresques du XII[e] siècle conservées dans le temple du Sauveur de Béréstovo.

On se propose de poursuivre les travaux de détachement des couches de mortiers couverts de peintures après la construction d'un pavillon spécial où les fresques du XVII[e] siècle ôtés du mur de la partie antérieure du temple devront être transportés.

MÉTHODES D'EXAMEN DES FIXATIFS À BASE DE POLYMÈRES SYNTHÉTIQUES

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On expose des méthodes d'examen des échantillons d'enduits de chaux fixés soumis à l'action des facteurs différents: absorption d'eau et rendement d'eau, humidification et séchage alternants, congélation et dégel alternants, effets de brusques changements de température, perméabilité à la vapeur, résistances à l'usure par abrasion et à la compression.

Dans tous les pays où les peintures murales ont été conservées, fût-ce des fresques, des peintures à la détrempe ou même des dessins rupestres préhistoriques - partout leur conservation, c'est-à-dire une élaboration des techniques de la conservation et de la restauration des peintures murales, soulève des problèmes particulièrement ardus. La solution de ces problèmes pose devant chercheurs une série de questions interdépendantes: l'examen de la composition et de la structure de l'enduit ancien et de la couche picturale, ainsi que de leur propriétés physico-chimiques et mécaniques; la préparation, sur la base de données obtenues, des échantillons de modèle qui les imitent; le choix et l'épreuve des fixatifs de polymères et l'élaboration de la technologie de la fixation; l'exécution des essais comparatifs de laboratoire et in situ des modèles*) consolidés et l'examen de l'influence des polymères sur les propriétés d'exploitation et décoratives des peintures murales. La solution de ces problèmes se heurte souvent aux difficultés liées avec un choix des

*) Les modèles - ce sont les échantillons qui imitent la structure, la composition chimique et les propriétés physico-mécaniques des enduits anciens.

méthodes d'examen, propres à fournir des renseignements sur des propriétés des mortiers anciens avant et après leur consolidation.

L'un des points fondamentals de ce problème c'est un choix des fixatifs et des essais de leurs résistances aux effets de l'atmosphère, c'est-à-dire aux variarions des conditions de l'humidité et de la température.

Dans la pratique de conservation ce ne sont pas seulement des matières traditionnelles qu'on utilise, mais aussi des matières nouvelles et des compositions de matières insolites, devant lesquelles des exigences particulières sont avancées. Pour cette raison les applications des essais des matières de conservation suivant les méthodes standardisées courantes sont limitées, et leurs résultats ne peuvent être utiliser, que pour une appréciation de certaines particuliarités de certaines matières. Dans le domaine de la restauration, les méthodes d'examen des qualités décoratives-artistiques des matières, par exemple, celles du contrôle des modifications de leur couleur et facture lors de la fixation avec des polymères aussi bien qu'avec des matières traditionnelles, en général, font pratiquement défaut. Cependant, au cours d'une élaboration des procédés de consolidation des peintures murales on ne peut pas se passer de données concernant la résistance, la solidité à l'eau, la perméabilité à la vapeur et l'autres propriétés des matières anciennes et des échantillons de modèle, avant et après de fixation. Mais pas toutes méthodes d'essai standardisées peuvent être employer à cette fin. Cela s'explique par une différence qualitative entre les propritétés des matériaux de construction vieillis des monuments ainsi que des modèles qui les imitent et celles des matières nouvelles. Les premières se caractérisent par une structure hétérogène, profondement decomposée, par une porosité élevée, par une résistance mécanique basse etc. C'est pourquoi lors d'application des méthodes standardisées ces matériaux sont incapables de maintenir la charge, comptée sur une haute résistance des nouveaux matériaux: ils se trouvent détériorés parfois même avant le commencement des épreuves (au cours de la fixation des échantillons sur l'appareil) ou fournissent des indices si contradictoires, qu'il ne reste aucune possibilité de les utiliser pour caractériser les propriétés réels des matériaux ou encore pour les comparer avec celles des matériaux fixés ou nouvaux. Pour cette raison, bien que les méthodes d'examens des matériaux de construction aient été prises pour base, il était nécessaire de les compléter

et modifier en tenant compte des traits spécifiques des travaux et matériaux de conservation. Les nouvelles méthodes d'essais ainsi que les expériences de laboratoire spéciales ont permis d'obtenir non seulement caractéristiques comparatives qualitatives, mais aussi bien celles quantitatives de nombre de propriétés des matières avant et après leur consolidation.

Les examens de laboratoire concernant des effets de différents agents sur matériau suivis d'une généralisation ultérieure des résultats, ne sont capables de répondre à la question sur la résistance d'un matériau dans des conditions naturelles d'exploitation. Par conséquent, les informations, obtenues lors des essais des matières, exécutés directement in situ, sur les murs, recouverts de peintures originales anciennes, deviennent très importantes.

Etant donné les traits spécifiques des matières à étudier, des méthodes d'examen visuel ont acquit une importance particulière; ils nous ont fourni des résultats précieux au cours d'investigation des monuments anciens et d'observation des fragments fixés des enduit anciens et des peintures murales dans des conditions naturelles. Les résultats des examens viluels sont photographiés.

Lors des épreuves des échantillons du mortier fixés une attention particulière a été accordée aux effets des agents principaux de déterioration des peintures murales. On a réalisé une série d'essais en vue de déterminer l'influence de l'humidité - un des agents les plus agressifs - en ensemble avec la congélation et le dégel alternants, l'humidification et le séchage. Le but des expériments était de définir l'influence de l'humidité sur résistance mécanique, aussi bien que la cinétique du processus d'absorption et de rendement d'eau, de perméabilité à la vapeur des échantillons avant et après fixation. La vitesse d'absorption d'eau, celle de rendement d'eau et la perméabilité à la vapeur des échantillons à la température ordinaire ont été choisi en qualité d'un critère d'appréciation.

Sur la base des examens des fixatifs pour des enduits, réalisés au cours de plusieurs années, on a élaboré des méthodes, qui permettent d'unificier les procédés d'épreuves de toutes les matières, employées dans le domaine de restauration des peintures murales, et notamment de la couche du mortier.

Méthodes de détermination de l'absorption d'eau lors de la consolidation des enduits

Les examens des peintures murales endommagées ont permis de constater, que c'est l'eau, qui est le principal agent de déterioration de la couche picturale et de l'enduit. Par conséquent, dans un milieu humide aux brusques changements de température, il faut prêter l'attention surtout à la stabilité des matières. Actuellement dans la pratique de conservation il n'y a pas de méthodes de détermination du comportement des fixatifs dans un milieu humide. Lors de la détermination de l'absorption d'eau le principe de la succion d'eau capillaire doit être appliqué.

Nous avons adopté une méthode, en partant des résultats d'analyse des procédés traditionnelles pour déterminer l'absorption d'eau des matériaux de construction, qui étaieut refaites conformément aux examens des matériaux à traiter. On a procédé comme suit: les échantillons, mesurant 20x20x20 mm, après avoir séché jusqu'à leur poids constant, étaient mis dans des cuvettes avec l'eau distillé (en plongeant dans l'eau 1/3 de l'hauteur d'un echantillon), à la température +20°C et d'humidité relative de l'atmosphère 65%, où ils restaient jusqu'à une saturation totale.

La quantité d'eau absorbée était contrôlée par un pesage des échantillons à 0,001 g. près, répété dans 3, 24, 72 heures. Chaque fois on tirait les échantillons de l'eau, en eliminant de l'eau de la surfaces avec papier à filtrer. On déterminé la quantité d'eau absorbée par un échantillon en % relativement au poids de l'échantillon sec d'après la formule:

$$C = \frac{(B-A) \cdot 100}{A},$$

où C - pour-cent de l'absorption d'eau (% d'humiditè dans un échantillon)
A - poids de l'échantillon, séché jusqu'à son poids constant
B - poids de l'échantillon saturé.

Méthodes d'examen du rendement d'eau des échantillons

Les méthodes de la détermination du rendement d'eau adoptées pour des épreuves étaient suivantes: on laissait reposer des échantillons, atteints leur saturation

totale, sur des plaques de verre à une température de +20°C et une humidité relative de 65%, on répétait des pesages de contrôle dans chaque 24 heures. Le rendement d'eau (l'eau, rendée par un échantillon) est déterminé en %, d'après la formule:

$$E = \frac{(B-C) \cdot 100}{A}$$

L'eau, qui est restée dans un échantillon, est déterminée d'après la formule:

$$K = \frac{(B-A) \cdot 100}{A} - \frac{(B-C) \cdot 100}{A},$$

où K - eau, qui est restée dans l'échantillon, en %.
A - poids d'un échantillon sec, en g.
B - poids d'un échantillon après saturation, en g.
C - poids d'un échantillon après avoir été exposé à l'air, en g.
E - eau, rendue par l'échantillon, en %.

On estime, qu'un matériau a passé son examen avec succès, si le rendement d'eau pendant 7. jours est égal 50%, en partant de 100% de saturation.

Méthodes de détermination de la perméabilité à la vapeur des matières à examiner

La valeur du coefficient de perméabilité, à la vapeur est une indice la plus significative du comportement des mortiers avant et après leur fixation dans des conditions de régime humide. La détermination du coefficient de perméabilité à la vapeur (M) des composées à examiner a été ramenée à la définition de la quantité de vapeur d'eau, passée à travers un échantillon plate d'enduit de chaux grâce à diffusion, avant et après sa fixation, en tenant compte de la différence de la flexibilité du vapeur d'eau sur l'un et l'autre côtés de l'échantillon.

$$P_n = \frac{\ell_n - \ell_{n+1}}{H_n} \qquad (I),$$

où P_n - quantité de vapeur d'eau (en g.), passant pendant une heure à travers $1m^2$ de la couche n du matériau, à condition, que cette couche se trouve en dehors de la zone de condensation $\frac{\Gamma}{m^2 \cdot \text{heure}}$;

$\ell_n - \ell_{n+1}$ - différence réele des flexibilités de vapeur d'eau, sur la surface de cette couche, en mm de la colonne de mercure;

H_n - résistance à la perméabilité à la vapeur de cette couche $\frac{mm \cdot heure \cdot m^2}{\Gamma}$.

La formule (1) donne une quantité du vapeur d'eau, passant pendant une heure à travers 1 cm^2 de la couche de matériau, dont la résistance à la perméabilite à la vapeur est égale H. Si la surface de la couche est égale F m^2, la quantité de vapeur d'eau passant sera portée au temps Z heures, et avoir remplacée H par sa valeur $H = \frac{S}{\mathcal{M}}$, nous aurons la formule suivante:

$$P = \frac{\ell_1 - \ell_2}{S} \cdot \mathcal{M} \cdot F \cdot Z \qquad (2),$$

où $\ell_1 - \ell_2$ - différence entre des flexibilités de vapeur d'eau d'un et d'autre côté de la couche, en mm de la colonne de mercure.

$$\mathcal{M} = \frac{P \cdot \delta}{(\ell_1 - \ell_2) \cdot F \cdot Z.} \qquad (3)$$

Donc, pour déterminer la valeur de coefficient de perméabilité à la vapeur d'un matériau "M", il est nécessaire de savoir les dimensions géométriques de l'échantillon (surface F m^2 et epaisseur S m.), la quantité de vapeur d'eau (P grammes), passée à travers l'échantillon pendant Z heures et les valeurs de flexibilités de vapeur d'eau $\ell_1 - \ell_2$ mm. colon. de merc. de l'un et de l'autre côté de l'échantillon.

Techniques des essais

La définition du coefficient de perméabilité à la vapeur des échantillons modèles s'effectuait comme suit. On a préparé des échantillons mesurant 50x50x20 mm. de matériau à examiner, par trois pièces pour chaque composé. On a placé un échantillon au-dessus d'une forme remplie d'eau distillée. Les bouts de l'échantillon ont été hermétisés par paraffine fondue. L'air à l'intérieur de la forme, au-dessus de l'eau, était entièrement saturé de vapeur d'eau, qui se diffusait à travers de l'échantillon. On comptait la quantité d'eau "P", passant à travers l'échantillon en pesant la forme et l'échantillon au bout du temps déterminé. Les expériences ont duré pendant quelques jours, on pesait les échantillons chaque jour, dans le même temps. On mesurait la flexibilité du vapeur d'eau à l'intérieur de la forme "ℓ_1" en consultant des tableaux de flexibilité maximale du vapeur d'eau, selon de la température de l'air dans la forme, etant donné que ce dernier était complêtement saturé de vapeur d'eau.

La température de l'air au-dessus de la forme était considérée comme identique à celle ordinaire, qui était enregistrait par un thermograph. On mesurait la flexibilité du vapeur du côté extérieur de l'échantillon "I_2" suivant de l'humidité relative de l'air et sa température. L'humidité relative de l'air ambiant était enregistrée d'une façon continue par un hydrographe, dont indications étaient contrôlées par un psychromètre à aspiration D'Asman, deux fois par jour. Un échantillon se présentait une plaque de 50x50x20 mm., ses dimensions géométriques (F et S) se sont mesurées à 0,1 mm près.

Les matériaux sont considérés comme avoir faits leurs preuves, si dans 30 jours leur perméabilité à vapeur se chiffrait à 50% en comparaison avec celle des échantillons (de contrôle) nonfixés.

Méthodes de détermination des effets de l'humidification et du séchage alternants

Les changements de l'humidité lors d'exploitation d'un monument nous incite effectuer des essais des fixatifs pour évaluer leur résistance à l'action de l'humidification et du séchage alternants. Etant donné l'absence de méthodes sur cettes questions, nous avons proposé une technique d'examen des fixatifs dans des conditions plus dures, que celles existant dans les monuments.

Description de la méthode

Avant procéder aux épreuves, l'échantillon sera mené jusqu'à un état de saturation d'eau complète, après quoi il sera subi à l'action cyclique de l'humidification et du séchage alternants. Un sycle d'épreuves se comprend donc les deux étapes:

1) Séchage des échantillons humidifiés en thermostat à une température de 45° ± 1°C pendant 8 heures. Après 8 heures du séchage on comptait le rendement d'eau des échantillons.

2) Saturation d'eau des échantillons pendant 16 heures à une température de 20°C.

Les échantillons à éprouver ont été chargés d'une façon cyclique pendant 90 jours. Ceux d'entre eux, qui ont supporté une charge cyclique - 90 cycles d'humidification et de séchage alternants sans endommagements apparents de surface, ont été subis à des essais mécaniques de compression.

Le matériau est considéré comme durable, dans le cas où après 90 cycles d'épreuves, la perte de résistance ne dépasse pas 20% en rapport de celle primitive.

Méthodes de détermination des effets de la congélation et du dégel alternants

L'exploitation des monuments pendant des saisons d'automne-d'hiver et surtout d'hiver - printanière impose d'examiner une influence des températures au-dessous et au-dessus de zéro, aussi bien que les effets simultanés d'humidité sur des fixatifs et la couche picturale d'un monument.

Dans la pratique des matériaux de construction il y a une méthode de détermination de la résistance au gel. Par résistance au gel nous entendons la propriété d'un matériau saturé d'eau résister à la congélation fréquente dans un milieu ambiant et au dégel dans l'eau alternants. Le dégel des échantillons plongés entièrement dans l'eau est inadmissible dans la pratique des travaux de conservation.

Une technique proposée par nous se comprend les étapes suivantes:

1) Saturation d'eau de tous les échantillons à éprouver à une température de +20°C, en les immergeant partiellement dans l'eau jusqu'au moment, quand ils atteigneront leur poids constant.

2) Une partie d'échantillons saturés d'eau a été gelée dans un appareil frigorifique à la température de -10°C pendant 16 heures.

3) Une autre partie d'échantillons saturés d'eau a été gelée dans des conditions naturelles d'hiver pendant 16 heures.

4) Dégel de tous les échantillons dans des conditions naturelles (à la température de +20°C et l'humidité relative à 65%) pendant 8 heures.

Les épreuves sont menées d'une manière cyclique. Un cycle se composait d'une congélation et d'un dégel. Les essais de la résistance au gel se consistent de 45 cycles de congélation et de dégel des échantillons, après quoi on détermine leurs résistances à la compression.

On a effectue une valutation de la résistance au gel suivant une indice de résistance du matériau à la compression après 45 cycles d'épreuves.

Méthodes d'examen de l'influence de brusques changements de température sur le mortier fixé

On détérminait l'influence de brusques changements de températures sur des échantillons fixés d'enduit pur dans une chambre avec un gradient de température de -40°C à +40°C. Nous avons humidifié d'eau des échantillons, mesurant de 50x50x20 mm., jusqu'à une complète saturation, après quoi nous les avons mis, pour une 1/3 de leur hauteur dans des cuvettes remplies d'eau, pour 24 heures. Puis, les échantillons saturés ont été placés dans la chambre. Les épreuves ont été réalisées comme suit: un cycle: 4 heures à une température de -40°C et 4 heures à +40°C; on effectuait 3 cycles par jour, le nombre général de cycles -100. Une fois les épreuves finies, on a fait un examen visuel des échantillons. Dans les cas, s'ils n'avaient pas des dégâts extérieurs, on effectuait des essais de leur résistance à la compression. Les matériaux sont considérés comme durables à l'action des brusques changements de température, si après 100 cycles, la perte de la résistance ne dépasse pas de 20% de la résistance primitive.

Méthodes de définition de la résistance à l'abrasion des échantillons consolidés

On a effectué l'examen de la résistance à l'usure par abrasion des échantillons fixés des mortiers purs à l'aide d'un appareil, muni d'une peau de polissage en qualité d'abrasif. Les échantillons de dimensions 100x70x6 mm ont été préparés d'un mortier de chaux-sable. On a effectué les épreuves d'une matières suivante: un abrasif, ayant la surface de 1 cm^2 était déplacé sur la surface d'un échantillon sous pression de 1 kg., faisant des mouvements de va-et-vient 20 fois. Après avoir fini cette opération, l'échantillon est nettoyé par jet d'air et pesé. On évaluait la résistance à l'abrasion de la couche du mortier fixée selon le poids des produits d'usure.

Les indices de la résistance à l'abrasion sont comptées d'après la formule:

$$K = \frac{(P_1 - P_2) \cdot 100}{P_1}$$

où K - indice de la résistance à l'abrasion, en %.
P_1 - poids de l'échantillon avant d'épreuve, en g.
P_2 - poids de l'échantillon après d'épreuve, en g.

Le matériau est considéré comme ayant fait les épreuves, si les pertes des poids des échantillons à traiter et ceux de contrôle sont comparables.

PROCÉDÉS DE MONTAGE DES PEINTURES À FRESQUE DÉPOSÉES DU MUR

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C'est à partir de 1966 que l'auteur a commencé à examiner des procédés de montage des peintures murales déposées du mur, quand la Commission réunie du Conseil de recherche et méthodes et de l'Inspection d'Etat pour la protection des monuments culturels du Ministère de la Culture de l'RSFSR a adopté une résolution d'ôter des murs de la cathédrale de l'Ascension (de l'autel latéral de Léonij) du Kremlin à Rostov les fragments des fresques conserves et de les compléter des morceaux du mortier peints tombés auparavant.

Les eaux souterraines venues d'une fouille ont inondé l'autel latéral, en détériorant le mortier et la peinture à tel point qu'il n'était pas possible les transporter, après la dépose, même à l'intérieur de la cathédrale.

Il était de toute urgence de résoudre une question d'un support léger et solide, sur lequel on pourrait monter la peinture, pour l'envoyer ultérieurement dans le musée.

Une méthode de montage de la peinture sur un bloc de mousse de marque ПС-I a été proposée et exécutée

par l'auteur.

Le méthode consiste aux opérations suivantes: on repose la fresque détachée face au sol, on aplanit le dos, on applique l'enduit et on rassemble tous ça avec un support de mousse, dont toute la surface est percée par perforations de 5-10 mm de diamètre, à distance de 25-30 cm l'une de l'autre. Ensuite, entre l'enduit et le support on incorpore, au moyen d'une injection, le mortier qui remplit les vides entre eux, aussi bien que les trous, à travers lesquels il était introdui, ce qui assure une cohésion solide entre le support et la peinture.

La mousse utilisée comme support a permis à bref délai obtenir un panneau solide et léger de dimensions souhaitables ayant une structure alvéolaire de surface qui favorise une meilleur cohésion entre le mortier et le support; elle donne également possibilité de ne pas recourir à fabrication des châssis et constructions employés jusqu'à présent. Etant donné la difficulté de réunir les matériaux ayant les différentes propriétés, les techniques précédentes avaient l'inconvénient d'imposer au restaurateur de construire et de fabriquer lui-même des panneaux, capables de former avec le mortier de chaux un corps solide, et pourtant, dans l'industrie, comme on sait, il y avait un grand nombre de panneaux solides et légers, de fabrication industrielle, par exemple, les structures à trois couches, connues également sous le nom structure de type de "Sendwich", qui peuvent trouver de large applications dans le domaine de la conservation. Il ne reste que réunir les matériaux possédant des propriétés physiques differentes, dont se compose l'enduit et le panneau.

Les techniques précédentes de fixation du mortier

sur les panneaux visaient, lors du montage, en assemblant deux divers matériaux, par exemple, l'enduit de chaux avec le bois ou métal, obtenir un bloc monolithique, c'est-à-dire, coller fortement l'enduit au panneau. Dans des conditions de l'humidité et de la température variables les tensions qui naissent dans cette structure entraîneront inévitablement la dégradation de la peinture.

Pour résoudre ce problème l'auteur a choisi une autre voie. Le principe de son procédé ne consiste pas à coller l'enduit sur un panneau, mais à faire retenir le premier sur la surface du panneau. Dans ce cas le support aussi bien que l'enduit pouront, lors des variations du régime d'humidité et de température, changer de volume indépendamment l'un de l'autre. On obtient cela en mettant entre le support et l'enduit un matériau à poil, qu'on fixe sur le panneau au moyen des colles insolubles à l'eau, et sur l'enduit - au moyen des solutions bien connues, utilisées en restauration (par exemple, la colle de chaux et de caséine employée couramment pour fixer des peintures, détachées du mur); comme support on utilise des panneaux de structure connue, par exemple les structures à trois couches, tandis que comme matériau à poil on utilise soie de porc dont un côté est fixé sur le support, et celui opposé reste libre.

On procède de façon suivante: on met l'enduit couvert de peinture face au sol, on applique au dos une couche de préparation (solution d'adhésif) ensuite on pose au-dessus de tout ça le support, prenant soin que sa surface à poil collé soit face au-dessous. Le poil plongé dans la préparation, appliquée au dos de l'enduit, assurera une cohésion solide entre le support et

l'enduit. On pourrait illustrer schématiquement ce cas en citant l'exemple d'une brosse à habit dont le poil est coulé par le mortier de plâtre; le plâtre y sera un enduit, tandis que le dos de la brosse - un support

Cette méthode a permis au cours de la restauration de fixer et de faire moins lourds les fragments de la peinture, monté auparavant sur les panneaux, faits sous la forme de châssis de bois parquétés dont les alvéoles sont remplis d'albâtre additionné de colle.

En 1939 par exemple plus de 150 m^2 des fresques ont été déposées des murs de la cathédrale de Trinité à la ville Kalazine. Les fragments détachés ont été fixés sur des châssis de bois parquetés. Pour éviter la chute de l'enduit à travers une grille, l'envers du châssis a été coulé de la solution d'albâtre additionné de colle. Ce travail a été exécuté par le peintre-restaurateur Gourkine P.I. qui décrit le procédé employé comme suit: "... on fait au préalable un châssis de dimensions convenables, renforcé par une grille (parquetage); on marque les quarts du châssis qui doivent recevoir la fresque. La grille est faite et fixée sans colle, qui gonflerait lors des opérations ultérieures; dans les divers endroits de la grille on percera des perforations au moyen d'un vilebrequin; on aplanit la fresque et on pose sur elle un châssis.

Après avoir ajusté le châssis, on l'enlève, on applique sur le dos de la fresque un mortier d'albâtre additionnée de colle végétale et, seulement après cela, on repose le châssis définitivement. La couche du mortier ne doit pas être épaisse, mais il faut l'appliquer de manière qu'elle penètre dans les perforations percées dans le châssis. Ensuite, on pose sur le châssis un charge et on enlève le mortier en excédent.

Dans 5-7 jours, à mesure que le mortier sèche, dans l'albâtre apparaîteront les fentes, lesquelles doivent être boucher.

On repète cette opération plusieurs fois. Puis, en dernière fois on coule l'albâtre, mais de façon que son niveau soit plus bas que l'hauteur de la grille, pour éviter l'augmentation du poids de la fresque". (Gourkine P.I., Rapport sur la dépose des fresques du monastère de Kaljazine, pp. 240-241).

Cette méthode a l'inconvénient que toute la structure du panneau commence à se dégrader ausitôt que le châssis de bois parqueté sera rempli par la couche d'albâtre, puisque le châssis de bois gonfle en absorbant une partie de l'humidité du mortier, ce dernier prend et perd sa mobilité; lorsque le mortier sera sec, le châssis séchera également, son volume diminuera, toute la surface de contact du mortier avec le parquetage se trouvera couverte de fissures, c'est-à-dire pratiquement la cohésion entre la couche d'albâtre doublant et le châssis sera perdue.

En vue de faire la structure plus légère, ainsi que d'assurer la durabilité de la peinture il était nécessaire de remplacer la couche d'albâtre du châssis par un matériau moins lourd, qui consoliderait la structure, préserverait la fresque contre son effondrement et assurerait une ventilation du dos de l'enduit. On arrivera à ce but en éliminant la couche d'albâtre du châssis et en le remplissant par éléments des constructions de chantier.

Lors du traitement de la peinture montée sur le châssis, dont les alvéoles sont remplies d'albâtre, on éliminera celui-ci, on remplira le châssis par matière de charge en nids d'abeilles qu'on fixera sur le châs-

sis au moyen des colles résistantes à l'humidité (par exemples celles à base de résines époxydes), et sur l'enduit - à l'aide d'un mortier de chaux.

Cette méthode employée pour la restauration des fresques montées auparavant sur les châssis parquetés dont les dos sont remplis par une coche d'albâtre permet, dans le cas des châssis anciens, de baisser le poids de la structure de 70-80% en éliminant l'albâtre et en le remplacant par une matière de charge plus légère, ansi qu'obtenir une ventilation de l'envers de la peinture.

Il y a plusieurs types de matières de charge pour les structures à trois couches. Parmi eux la matière de charge en nids d'abeilles aux alvéoles hexaèdres, citée comme exemple, est la plus répandue.

Dans la pratique de restauration parfois il est nécessaire de remettre l'enduit peint détaché du mur à sa place à quelque distance d'une paroi, c'est-à-dire de manière qu'il soit une couche d'air entre le mur et l'enduit, qui joue le rôle de la couche isolante ayant pour but d'éviter une migration de sels solubles à la surface de la peinture. A cette fin un élément de standard est construite sous forme d'une plaque polygonale ayant au dos une cavité ouverte à surface sphérique. Des éléments fabriqués d'un matériau léger peuvent être recollés ensemble en forme de panneaux de dimensions nécessaires aux joints rénforcés.

Cet élément est destiné principalement à être employer comme matériau de revêtement du mur en briques sur lequel on fixera l'enduit peint. Pour imiter la maçonnerie en briques, la plaque de revêtement doit être exécutée en argile cuite; le côté à la surface sphérique est couvert d'une glaçure résistante à l'eau. On fixe

la plaque sur le mur à l'aide des crampons métalliques, on protecte les joints contre l'humidité et on les mastique, on fixe l'enduit sur le mur revêtu au moyen d'un mortier de chaux.

Les plaques de telle structure, se trouvant sur la surface de la maçonnerie et y adhérant solidement, ne la recouvre qu'une façon minimum, en assurant en même temps la présence d'une couche d'air entre le mur et la structure; cettes propriétés peuvent être utiliser dans tous les cas quand il est nécessaire faire une couche isolante, tout en conservant les fonctions particulières de l'architecture du monument dont elle remplissait avat sa restauration.

Il est très difficile par exemple veiller à la conservation du toit, qui protecte les voûtes peintes contre l'infiltration d'eau, surtout dans les monuments éloignés. Parfois, même si on avait détecté les dégâts du toit, il n'est pas facile d'éliminer les coulages. Dans ces cas les plaques en argile cuite, appliquées sur la voûte à sec et puis recouvertes d'une couche isolante, permetteront protecter la peinture contre l'endommagements, en conservant en même temps la ventilation des voûtes.

Ces plaques peuvent également être employées avec succès en vue de la protection de la peinture contre infiltration de l'humidité des monuments dont la paroi intérieure se trouve, par sa grande partie, au-dessous de niveau du sol extérieur.

RESTORATION OF ANCIENT MONUMENTAL PAINTING IN CULT BUILDINGS

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Ancient wall-painting which has been preserved in fragments or completely in more than 300 churches of Georgia is of great interest. As it covers in its development a period from X to XIX c. there exist both modest provincial works of art prominent ones.

Painting has been preserved not only inside of buildings but on the external walls of some churches. There is both religious painting and painting of secular content (images of state workers, ktitor portraits)

Important religious and political events has influenced on the formation and development of Georgian monumental painting.

Georgian church as iran and armenian ones at first inclined to monophisit teaching. But after Chalchedon council (451 A.D) it joined the Orthodox church which gained a victory (VI-VII A.D.). Since that time culture connections with coreligious Byzantium became more intensive. Having many common features with the monuments of Byzantium world, Georgian monumental painting has its unique quality. It go back to traditions of monuments of Eastern Christianity due to its tendency

to cover walls with compositions completely. (We keep in our mind kappadokian paintings covering walls as a tapestry).

There existed a tendency towards logistic clearness and strict dependence the painting on architectonics of inner space in the Georgian painting of those time. Linear character which is particular characteristic of Georgian monuments of XI-XIII cc. has been expressed b the combination of local colour spot and line. These features differed Bizantium monuments from Georgian ones.

Wall-painting of Georgian churches was greatly dama ged of time and enemy invasions.

Since 1950 systematical works on cleaning and conservation of ancient wall-paintings started in Georgia after Particular Scientific Restoration Workshops has been formed in Tbilisi.

Concervation of the following monuments has been carried on:

Nekresi - three-nave basilica of VII-VIII c. - fresco of XVI c.

Palendgiha - domed church of X-XI cc., renewed in XIV - fresco. As preserved inscriptions tell us this cathedral was painted in the order of ruler of Mingrelia - Vameka Dadiani - (1386-1396 A.D.) by byzantium painter Kir-Manuil Eugenic.

Kortscheli - domed church "Gotismshobeli" (Bogomateri) of XII - tempera painting of XII with the pictur of ecumencial councils in narteks and painting with th image of king David Narine in the side-chapel.

Plaster layer under fresco is very thin and was placed on the wall of stone.

Athenis Sioni - domed church of VII c. - tempera painting of 1080 y.

Manglici - domed church of VI-VII c., rebuilt in 1020 - tempera painting of the thirtieth of XI c.

Vardzija - semi-cave church of Bogomateri of XII-tempera painting of XII-XIII.

Kintsvisi - domed church of St.Nicoloza of XII-XIII-tempera painting of XII-XIII.

Martvili - domed church of VII with renewal of - tempera painting of XIV-XVI.

We must dwell on cleaning and conservation of wall-painting in the monuments of Alaverdi, Timotesubani and a number of churches of Svanetia.

All the painting of Alaverdi cathedral of St. Georgij (Khahetia) has been coverd with plaster whitewashing in three layers, which crumbled and painting fragment has been discovered. This caused cleaning the wall surface at first in fragments and then as a whole.

Restorers cleaned about 800 m^2 of wall painting of various style and time (from XI to XIX). Among them there is a splendid image of "prelate" (svjatitelski tchin) of XI (tempera) - in altar apse and ktitor images of Khahetian kings of XV (fresco) - in the southern apse. At the end of altar apse there is a fresco of Madonna with Infant and archangles. In the upper of levkas (glue-chalking ground) (thickness is about 0,5-1,5 cm) there are traces of fillers-coal and straw.

In Timotesubani, church of St.Nicolaj, painting executed in secco, is dated from XII-XIII on the basis of iconographical and artistic-stylistic analysis. It is an epoch of outstanding georgian poet Schota Rustaveli marked as renessance of all sheres of art and literature.

Iconographical scheme of painting is typical for georgian crusi-domed cathedrals of this time (Kintsvisi, Betanija and others).

In the shere of dome there is an enormous cross in locket. Over the windows there are Deisus and archangels, lower there are prophets and saint fathers of church. In subdomed pendentives there are evangelists. In the altar apse there is Madonna with Infant with ar- changels, epistle of apostols and prelate. Northern an southern part of composition were pictured with scenes of festival cicle. Western part of composition shows Last Day.

There are saint warriors, saint women, anchorites i the southern-western and northern-western spaces.

Painting was greatly damaged and crumbled with plaster from all archs and from the walls of western part. Flaking, dispersion of paint layer and crystall salts were observed. Besides that all the walls were coated with pigeon farrow. Partly cleaning by mechanical way is accompanied with conservation of paint layer. To strenghen plaster layer plaster solution of the highes quality is applied.

In Svanetia much of small churches of sual type wer preserved, the interior of which is painted. Among the there are works of tzar's painter of XII Tevdore. Iconography of svan paintings are the scenes of festival cicle - Birth (Cristmas), baptism (Epiphany), crusifixion, descending the Hell, images of saint Georgij (Sva Dzrag), Barbara Kvirike and Iblite.

Particular honouring these christian saints is base on the indentification them with the divinities of ancient cults.

It is known that saint Georgij replaced ancient divinity of Moon (Selena), and in Svanetia he took first place among Christian saints; saint Barbara is identified with the divinity of Sun (Sol), called as Barbar and saint Kvirike is identified with the divinity of hunting.

At the end of althar of svan churches there was image of Deiusus (up to the breast) sometimes composition of glorification of Christ, where Deisus is connected with the conception of protection for world, put foward by new testment church and old testement church. This idea is expressed the images of such apocalyptic preachers as seraphim (six-winged angel), tetramorph and symbols of evangelists.

Colouration of svan paintings is based on combination of red-brown, grey and ochre pigments.

Technology of painting is tempera. Ground - is thin, microdispersed, plaster levkas, in one layer, without fillers.

Paintings of Svanetia were greatty damaged of atmosphere precipitation, of smoke of sacral fires, made by believers in the special side-chapels "Ladbashagh" to bake ritual bread.

For last years conservation works has been carried out in the following churches:

Iprari-Tarinzel (Archangels) of XI - tempera painting of 1096 by Tevdore.

Khe-Barbal (st. Barbara) of XI - tempera painting of XVI.

Matskhvarshi - Matskhvar (Spas) of X-XI - tempera painting of XII by painter Michaela Maglakeli.

Georgia is rich in cave complexes, Garedgij cave monasteries being the outstanding ones. They are si-

tuated about 60-70 km from Tbilisi at the distance c 25 km from each other. Bared rocks covered with gras which drys up early in summer, abseucl of water - al of this characterizes the area where monasteries ar situated.

The founder of the first monastery of all the gr is saint David called Garedgy, one of the so called sirian fathers who came from Mesopotamia in VI c.

The refectories of monasteries in Udabno (the be ginning of XI c.) and Bertubani (XIII c.) are of pa ticular interest among preserved monumental painting

Paintings of refectories of monasteries in Gared are laconic expression of main idea - euchararisty. Iconography of painting is composed of scenes conne with the subject of meal "Troitsa", "Miracle of inc asing bread", "Recieving the eucharist with bread a wine".

Paintings of David-Garedga monasteries are execu in tempera; ground of gantch is two-layer. The firs layer of coating evened the surface of hewn stone, second one (thickness in 1-1,5 cm) prepared smoothl surface to be painted.

We must dwell on restoration works carried on in David-Garedga such as taking off painting with imag of tzaritza Tamara, tzar Georgij and tzesarevitch Georgij Lasha, transferring it in State Museum of Georgin Art in Tbilisi.

The process of all the restoration works is desc bed by restorers in special scientific account. Tec cian documentation (drawings in the scale 1:25 work out in detals) serves as illustration to it.

A STUDY OF ORGANIC COMPONENTS OF PAINTS AND GROUNDS IN CENTRAL ASIAN AND CRIMEAN WALL PAINTINGS

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Summary

Glue-based paints were used for antique and early medieval paintings of Central Asia since a mixture of amino acids and polysaccharides was isolated from specimens of 2nd century B. C. to 7th century A. D. In some cases gelatin glue and in other gum glues were employed as binding medium of paints and grounds. Both these types of binding medium were widely used in medieval Indian art. Analysis of a specimen of monochromatic antique Panticapean painting showed that the paint layer consisted of ochre and $CaCO_3$ thus implying that the painting was done in fresco technique. Beeswax isolated from the specimen was probably applied to the walls after finishing the painting.

The technique of antique and early medieval wall paintings of Central Asia has not been accurately studied though it was suggested (1) that ancient artists used glue-based paints. Fragments of antique Black Sea coast wall paintings excavated in Crimea have not been investigated. The present communication describes isolation and identification of organic components of some of these paintings.

Samples of Paintings

1. Central Asian buildings: Parthian temple Mansur-Depe, 2nd-3rd centuries B. C.; Bactrian Buddhist temple complex Kara-Tepe, 2nd-4th centuries A. D.; Khoresmian palace Toprak-Kala, 3rd-4th centuries A. D.; Sogdian palace in Pendjikent, 7th-8th centuries A. D.; Buddhist temple Adjina-Tepa, 7th century A. D.; Tash-khauli palace, 1830, in Khiva. In all cases small specimens of 3 - 5 cm^2 were used with poly- or monochromatic paint layer. The painting from Mansur-Depe was done on chalk ground 2 - 3 mm thick, the one from Tashkhauli on lime plaster and the rest on 1 - 2 mm thick plaster ground.

2. Crimean buildings: fragments of yellow paintings on thick lime ground found during excavations of Pantikapea (Kerch), Crimea.

Results

Table I shows the results of quantitative analyses of amino acid mixtures isolated from ground and paint layers of Mansur-Depe wall paintings. The mixtures were isolated on a Dowex 50 x 2 ion exchange column and analysed on KLA-3B Hitachi Analyser. As is evident from the Table, no hydroxyproline whose high concentration is characteristic for collagen and gelatin was detected. However, significant percentages of proline, glycine, alanine and glutamic acid make it possible to conclude that gelatin was used as binding medium but later degraded to individual amino acids. The absence of hydroxyproline can be explained by its higher lability as compared to other amino acids.

Fig. 1 shows IR-absorbtion spectra of substances isolated from specimens of Central Asian wall paintings by successive extraction with water, HCl, NaOH and purified by dialysis against water. The comparison of the spectra reveales their striking similarity and a pattern characteristic for polysaccharides (2,3).

The spectra of (b) and (c) compounds are very much alike; the similarity between these polysaccharides was also confirmed by the analysis of their composition by

Table I. Amino Acid Composition of Mixtures Isolated from Ground and Paint Layers of Mansur-Depe Painting

	Ground		Paint layer	
	M	mol%	M	mol%
hydroxyproline	-	-	-	-
asparatic acid	0.0237	4.5	0.0834	6.7
threonine	0.0109	2.1	0.0142	1.1
serine	0.0310	6.1	0.0522	4.2
glutamic acid	0.0730	14.4	0.1505	12.0
proline	0.0370	7.3	0.1024	8.2
glycine	0.0855	16.9	0.5180	41.5
alanine	0.0642	12.7	0.1880	15.1
1/2 cystine	traces	-	0.0290	2.3
valine	0.0218	4.3	0.0312	2.5
methionine	0.0060	1.2	0.0117	0.9
isoleucine	0.0109	2.1	0.0118	0.9
leucine	0.0340	6.7	0.0285	2.3
tyrosine	0.0127	2.5	0.0155	1.2
phenylalanine	0.0126	2.5	0.0131	1.1
lysine	0.0397	7.8	-	-
histidine	0.0440	8.7	-	-
sum total	0.5060	100.0	1.2495	100.0

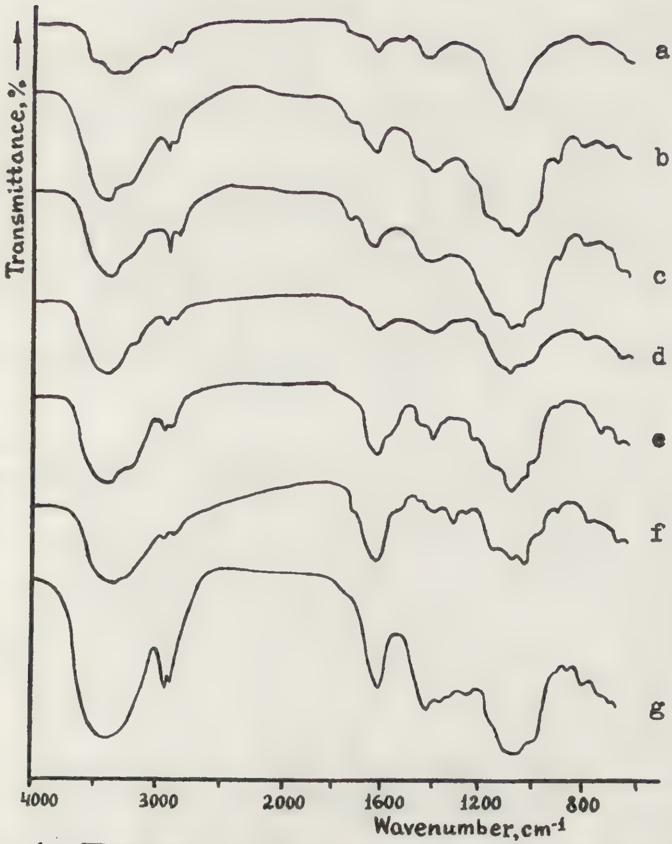

Fig. 1, IR-spectra of polysaccharides from specimens of Kara-Tepe red paint sample (a), Kara-Tepe polychromatic sample (b), Pendjikent (c), Adjina-Tepa (d), Toprak-Kala (e), Tashkhauli (f) and of apricot gum (g). (Perkin-Elmer Model 257, KBr pellets)

means of thin-layer chromatography on cellulose (100 : : 35 : 25 ethylacetate-pyridine-water system): in the hydrolysates of both substances mannose and glucose were shown to be the major components. However, gas-

-liquid chromatography (Pye Argon Chromatograph, 3% ECNSS-M on Gaschrome Q column, 180°) of acetylated derivatives (4) of (c) substance has shown that it contains significant quantities of galactose and glucuronic acid as additional components (Table II). It seems,

Table II. Composition of Polysaccharides Isolated and of Apricot Gum

polysaccharides	arabinose	ramnose	xylose	mannose	glucose	galactose	glucuronic acid
a			+	+	±		
b			+	+	±		
c			+	+	+	+	+
d			+	+	+		
e	±			+	+	+	
f	+			+	+	+	
apr.g.	+	+	+	+	+	+	+

that gums of similar but not identical plants were used in these two cases. These could not be the gums of cherry or apricot since they must necessarily contain relatively high amounts of arabinose and galactose (5). Yet it cannot be excluded that (b) and (c) polysaccharides represent gums of certain trees of Prunus genera or Prunoideae subfamily which were shown to contain up to 90% of xylose residues (5).

The spectra of (e) and (f) polysaccharides are the most similar to the spectrum of apricot gum. Their more intensive absorbtion bands in the regions 1400 - 1420 cm^{-1} and 1620 - 1640 cm^{-1} are probably due to the presence of dissociated carboxyl ions (3) and the band in the region 1240 cm^{-1} to the presence of inorganic components. Chromatography of hydrolysates of these polysaccharides revealed monosaccharides characteristic for the gums of fruit trees (Table II). In other words, apricot or cherry gum was probably used in these cases.

Neither the spectrum of substance (d) nor its polysaccharide composition allow to refer it to any specific plant gum.

The presence of gelatin and gum-based binding media in paints and ground are in good correlation with ancient Indian techniques of preparation of grounds and paints(6).

Using IR-spectrometry the paint layer of a specimen of yellow Panticapean painting was studied. It turned out that the spectrum of chlorophorm extractable substance (Fig. 2 a) is that of beeswax (7). The wax is clearly bees and not Punic since its spectrum lacks the band at 1570 cm^{-1} which is characteristic for ionized carboxyl groups of the fatty acid soaps present in Punic

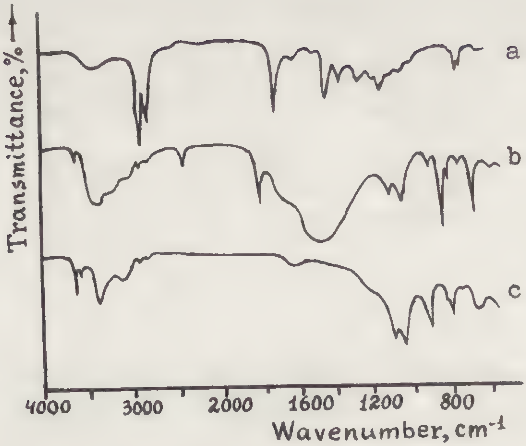

Fig. 2. IR - spectra of beeswax (a), yellow paint layer (b) and ochre (c).

wax. (7).

After the removal of wax virtually no organic components remain in the paint layer: in the spectrum of the pellet one can see extensive bands representing $CaCO_3$ (at 1430 and 835 cm^{-1}) and, probably, yellow ochre (8)(Fig. 2 b). The presence of the latter is evident from the fact that after $CaCO_3$ is removed by washing with HCl a mixture of clay minerals, kaolinite (Fig. 2 c, bands at 3700, 3620, 1090, 1015, 915, 695 cm^{-1}) and montmorillonite (bands at 3620, 1100 and 795 cm^{-1}) remain in the pellet. In addition, a broad band at 3130 cm^{-1} reflects the presence of iron hydroxide which is a characteristic constituent

of natural yellow pigments (8). The presence of ochre and $CaCO_3$ in the paint layer suggests that the wall painting was done in the fresco technique. As for wax detected in the samples, it was probably used for covering of already finished paintings.

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FIELD RESTORATION WORKS 1972-1973 IN AFGHANISTAN

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Since 1969 soviet-afgani archaeological expedition has been working in Afganistan. The main task of the expedition is to compile an archaeological map and to study monuments of culture in the Northern Afganistan. Toward this end in view large-scale prospecting works are being carried out and some monuments are being excavated.

The most interesting object is an antique settlement in dwelling houses and cult places of which a great number of wall-paintings were discovered. Settlement Dalversine is sutuated in the northern part of Afganistan, 47 km from Balha, formely the capital of Greeko-Bactrian kingdom. This settlement had been existing for some centuries from III B.C. down to V-VI A.D.

It appears to be a former large-scale administrative centre. Its lay-out is more or less customary for large settlement of this era. The settlement was enclosed with high defensive walls fortified with towers. The area within the walls of the town is about 12 hectares. In the centre of the town a citadel rises. Among the citadel and the external walls dwelling houses

and cult places were situated. Settlements with wooden buildings, country-estates, temples were located outside the town. The fragments of paintings discovered in Dalversine belong to different culture epochs and are the worthy sources showing an evolution of artistic traditions from the date of monuments of Greeko-Bactrian kingdom to early middle ages inclusively. It is particularly remarkable that wall-paintings which were being drawn for long-time period belong to one and the same historian cultural complex and give us an opportunity to get an idea of stylistic and technological transformations which took place for this period in the Central Asia and areas neighbouring with it so that parallel with restoration works painting technique and technological methods with aim of which wall-paintings are drawn are studied; the composition of the grounds and painting pigments are analysed.

All mural paintings are done in the glue painting technique; painting is applied on either suspended loess or gantch. Over earlier paintings a renewal layer was often placed or an original painting is overlapped with a new ground which is followed by a new painting.

Most of compositions were bad preserved up to our time. The great part of losses in painting can't be restored because painting layer is lost with the plaster or ground together. For the period of excavations about 30 m^2 of wall-paintings have been discovered. Amongst them the earliest and most interesting preserved paintings are two compositions placed on the external side of eastern wall of town's temple. There is a naked youth holding the horse by the bridle on each composition. These paintings are likely to be devoted to heroes of ancient greek miphology - brothers Castor and Poli-

derk (Dioscurs). The upper part of the compositions have been completely lost. The fragment of preserved painting (left composition) measures 2,3 m x 1,5 m. Inside this temple there is a remaining preserved wall painting which is likely to show one of the main gods of Indian pantheon - Schiva.

He is depicted with Parvati, sitting on a bull. The top of the painting wasn't preserved; all the remaining composition may be read ( ) as a draft sketch owing to remaining painting layers. This fragment measures 2,3 m x 1,8 m.

Some fragments of paintings were discovered in one of the buildings, contiguous to defencive wall. There are shown sitting personnes. These paintings have an curious peculiarity - they contain some incriptions over every personne.

This painting is greatly differed from the first two compositions and belongs to the latest period of town's existing as the analysis of painting technology and artistic style shows. The most remarkable fragment measures 2,1 m x 1,1 m.

Close to this building two preserved fragments are placed on both sides of a doorway. One of them shows a warrior in a sharp motion. One could read that part on which torso and hand drawing the sword are designated. The other one - the lower part of a composition shows two feet trampling on cranes.

These fragments measure 1,3 x 1,0 m and 1,25 x 0,8 m accordingly.

Outside the town about 100 m from south-eastern defencive tower under the excavations Buddish sanctuary was discovered.

Some fragments of paintings showing a mortar and a

procession, probably, of monaks were seen on a wall of its central building where preserved fragments of the mortar and sculpture portray of Budda have been found.

Under field restoration the principle task which faces restorers is to preserve painting discovered, to take it off the walls and was sent at the Institute of Archaeology in Kabul.

As every fragment of painting was being cleaned and preserved it is described in view of painting techniques and means of painting, samples for analysis were taken, wall-paintings are copied, photographs and measurements were taken.

The generally accepted technology of restoring wall-paintings in the field was chiefly used.

When selecting materials and technology we come from the following:

1. Field preservation is a temporary one hence basic stabilizing material must possess such properties as permit a secondary treatment of painting surface in a mastershop.

2. The composition to stabilize the painting surface and the composition to glue reinforcing material (cloth, paper) must be solved in varions solvents so that the painting layer wouldn't be destroyed when protective papering are taken off.

The method of preservation of painting fragments worked out and used successfully for many years at restoration laboratory of State Hermitage was taken as a principle.

Stabilizing the painting is produced with low viscous solution of PMBA in Ksilol. The state (appearance) of the painting surface of fragments makes it difficult to treat painting layer satisfactorily and preserve it

completly in the field conditions.

Besides that is desirable to give an abundance of PMBA on the surface and inside painting layer in order to guarantée the protection of painting layer when taken off, transported and kept.

That is why one of the main requirements to properties of stabilizing material must be its reversibility, i.e. capacity to be solve again and to be removed partly or completely from painting layer.

Low viscous PMBA is especially sutable material for these purposes as it posseses this important property.

Then, it is inevitable for breaking stress to emerge and have an effect on uneven surface of most of painting fragments.

As temperature of its vitrifying is comparatively low (about 20°) PMBA is enought elastic in general conditions and release an effect of deformed stress.

To glue stabilizing material (cheesel-cloth) 10% polyvinil alcohol solution in water is used. It is the water that is practically used as a solvent for this polimer. There are merits and demerits in this situation: As it is difficult to supply the expedition with large quantities of organic solvents using the polymer which is solved in water simplifies this problem.

On the other hand, in the conditions of the hightened relative humidity of air or when it rains it is practically impossible to use polyvinyl alcohol. But in the conditions of hot and dry climat of the Central Asia it is expedient to use this substance. This material may be assumed to be quietly suitable for glueing the stabilizing material to painting surface. It seems to possess a number of technological advantages which based on its physico-chemical properties when used with PMBA together.

Firstly the existence of a large quantity of OH-groups in polyvinyl alcohol (about 38%) which were greatly connected by means of hydrogen bonds (about 70% under 20°), provides high temperature of vitrifying, highten strength, and very low gaz penetrability of this polymer. High strength properties of polyvinyl alcohol (limit of bending strength is 650 kg/cm^2), are the same ones even under the highest temperatures of air which characterize the hottest seasons in this area. These properties are combined well with an elasticity of PMBA. Really the surface of large quantities of painting fragments became deformed (————————) in time - difference in surface levels reach to 6 cm here and there. It is of great importance for the uneven surface of painting fragments to be stabilized when transported and kept for a long-time.

Usually after long-time drying painting fragments which follows stabilizing their surface with the aim of PMBA there remains comparatively large quantity of the solvent (Ksilol) in the film of PMBA. Under keeping the walls paintings taken off the remaining ksilol will aid to evaporate through the painting surface and cause the overdrifting of PMBA in the substance of fragment, its moving to the painting surface. Very low gaz penetrebility of a film of polyvinil alcohol prevents this process, decelerates the process of complete drying and directs it backwards, causes the overdrifting of PMBA inside loess layer. After moistening painting fragment with hot water a cheesel-cloth and a film of polyvinil alcohol is slightly taken off the painting surface at the stage of complete treatment of wall paintings it is important to choose material which would satisfy for decorative and technological requirements.

Those properties of PMBA which were positive in the field became the properties of negative character when the painting is exposed. Low temperature of polymer's vitrifying results in being PMBA film at high elastic state when kept in general conditions or when exposed results in possesing such property as cold fluidity and property to collect a dust on a film surface.

Besides that one can slightly impregnate deeply porous structure in the field and slightly as well remove PMBA partly or completely from the painting surface in a laboratory. On the other hand, it is the low molecular weight of this polymer that causes filling pores of pigment layer and loess ground with PMBA enough closely and condencing its structure, then causes darkening loess surface and changing colour of painting layer. The colour of those painting layers where is used mixed pigment greatly changes particularly, for example red and white pigments are mixed to produce pink pigment or when a pigment is applied on the white ground. Treating paintings firstly in the field such a property of PMBA of low molecular weight often simplifies greatly reading painting fragments preserved badly as intensity of tone of black and red pigments. So stabilize completely painting surface it is important to choose another material deprived of shortcomings the above mentioned.

The material to be suitable for these purposes as it seems to us is co-polymer of BMA with meta-kril acid (BMK-5) introduced into restoration practice by scientific worker of VCNILKR Copolymer which is prepared with the aid of polymerization of BMA and small quantity (5%) polar monomer, in this case, MA acid. It is quite different from PMBA. It possesses high surface solidity and temperature of vitrifying (65°C), better

adhesive properties. But at the same time simulteneeusly it possesses all properties of polymers of ethers of MA acid: colourlessness, high light and atmosphere resistanse, resistanse to water.

As PMBA moves inside the substance of painting fragments BMK-5 may be used to stabilize surface of painting layer and comparatively high viscosity of this polymer isn't obstacle for this task.

Thus, painting surface of picturesque fragment became practically stable for any changes of temperature of ~~(environment)~~ surroundings.

Shortly, technological scheme of preservation of wall-paintings placed on loess ground is the following. Discovered fragments are stabilized with ksilol solutions of low viscous PMBA.

Last impregnations are carried on with concentrated acetone solution of PMBA to form continions surface film. As some days (twenty-four hours) pass after drying stabilized painting surface is glued with 2-3 layers of cheesel-cloth impregnated with 10% aqueous solution of polyvinil alcohol. Then, with the aim of veneer sheet painting fragments are taken off the walls; back side of fragments is cleaned; the loess stratum of 6-8 mm thin and is stabilized with the solution of PMBA and is glued with cheesel-cloth. Prepared in such way painting fragments are transported and kept. In a laboratory a cheesel-cloth is taken off the surface painting, fragments is placed in a special box, where the abundance of PMBA is distilled from painting layer.

Then, painting is cleaned from loess; painting surface is made even. After painting is stabilized completely with BMK-5 painting fragments are mounted on the penoplast shields.

Glueing the fragments to penoplast is produced by alcohol solution of polyvinyl-butiral. During two field seasons 27x2 wall-paintings were taken off the walls and transported. Laboratory treatment of painting fragments are at the point of beginning.

As well analitical investigations of pigments and paints were worked out; data on technicks and technology of wall-paintings in settement Dalversine are obtained and treated.

SOME EXPERIMENTS ON STRENGTHENING OF ANCIENT WALL PAINTING SUPPORTS WITH LIME-CASEIN SOLUTION

D.E. Bryagin

USSR

Twenty-five years long use of lime-casein compositions for strengthening of cleavaging, crackling and come off the massonry plasters of architectural monuments of the Middle and North Zones of European Part of the Soviet Union showed good results. The strengthering quality depends on initial materials espesially on slaked lime washing free of soluble salts, purity of filling powders (pumice, burned ceramics and sand) and on the observance of precaucions in process of injection of composition.

In Middle part of Russia monuments of Old-Russian painting have different preservation of ancient plaster that depends first of all on climatic conditions, structure of monument, massonry material as well as on regime of temperature and humidity.

For the most momuments these conditions unfortunatly were not optimal ones that has resulted in cleavage of ground and its support, and in some cases dividing of this ground into some layers and its crackling througn all its depth. The net of cracks has various character which depends on lime and filler quality. Almott every being restored momuments meeds in a lot of work for ground strengthening.

The strengthening of plaster ground of ancient monu-ment is main process that determines subsequent preser-vation of painting therefor Russian restorator of all generations gave much attention to it. In Russian resto ration practice many different methods of ground streng thening were used including

The principal technique was and is injection of strengthening composition into cavity between ground and support.

Since early XX and up to 40 ths gypsum and more seldom cement vere used. But time has prooved that they not only had needed effect, but on the contrary favour further decay of painting.

Proceed from the fact that ancient painters not seldom used albuminous vehicle (hen egg) or cereals water when they prepared lime grounds it was decided to

try for injection lime-casein composition. The main proportion of choosen by us solution was following: one part of casein to three parts of water and then one part of resulting solution to three parts of slaked lime. But concrete conditions sometimes makes it to deviate from the main proportion to one or another side.

Works begin with composing of topographical scemes of restored paintings on which areas of loose ground, later inpaints, feasures and so on are fixed. Based on the result of painting examination paints for injections are chosed. It depends on the character of pictural images, conditions of paint layer and above all on cleavage of ground, disposition of voids and destruction degree of monument massonry. It is preferable to use for boring of openings areas of paint layer loses, features in plaster and later inpaints.

Methodics of plaster ground strengthening by means of lime-casein solution was worked out by V.E. and D.E.Bryagin.

The strengthening process begins with boring of openings, blowing through and thorough washing through them of ground cleavage cavity. If there are large splits they must be caulked to prevent leakage of solution. Then the solution is injected. This injection must be done with much care to fill all cavities, some

of which can be considerably remote. It is sometimes difficult to reveal connection between cavities with preliminary viewing and being injected the solution can come in some remote cavities where as it seems it must not come in.

Injections must be done by means of rubber pear provided with metal removable point. Having it taken off you may easily and quickly fill the pear with solution.

The restorer must appreciate the streanght of solution pressure in cavity to be filled and in due time to stop injection to prevent breaking of plaster layer and its destroing. Filling of cavity must be immedeatly stopped as soon as even very low hardly appreciable from out side pressure occures in side it.

In restorational practic there are not only grounds that cleaved from their support occure but those that have descomposed plastering as well.

Consolidation of ground with net of fine cracks is not very difficult tusk if you use lime-casein solution In this case the solution must come into cavity until i appears in cracks net, then feeding is temporary stoped to let the solution set into cracks. Due to high abilit of solution to set these pauses are negligible and don' exieed 2-3 minutes over load of cavity with solution is

inadmissible due to possibility of splitting and damaging of area to be strenghtened. (In seldom cases when there are some large splits this interval becomes longer). Then injection is repeated and only when all cracks will be completely filled the main cavity is filled.

The consolidation of cleavaged ground is more difficult tusk. It largedly depends on master's skill. The main tusk is to judge the depth of intermediate cavities of cleavaged ground. The points for drilling are to be chosen in such manner that it will be possible to consolidate adjacent cavities of exfoliation being on different levels in depth of plaster layer. Errors and inaccuracies are especially fraught with undesirable consequences, on which the quality of restoration is depend.

If wall-painting survived only as fragments edges of original ground are puttied with solution consisting of: slaked lime, sifted quartz sand and crushed bricks, finely minced linseed fibres and casein.

Pouring of lime-casein solution is performed as a rule in twothree treatment. The first is done with a fresh mortar, but subsequent ones with mortar that was stood at list for three days. For pourings of large cavities fillers (the best of which is crushed pumice)

are used. In seldow cases when there are very large and deph of fissures both in ground and in masonry quartz sand is used. Two-three days intervals are necessary between such pouring to let injected solution become moist less and strong.

During pouring it is necessary to press the loosened plaster to which end spring clamps may be recommended. Rigid clamps are in effective being used on scaffolding due to mobility of the latter. A spring in any case garantees for necessary minimum of pressure. Using them one can make solution adgesion with plaster and masonry to be more strong and escape of ground capping that rather oftenly appears in areas where it is loosened. The pressure strength can be different depending on density of injected mortar and thickness and durability of ground to be consolidated. If ground is thin and brittle the pressure must be low but with especially thick grounds it is necessary to use spiral clamps (screws), because springs can not provide it with due exertion.

Ground is to be consolidated during warm seasons because for its perfect drying it is necessary to have two-four weeks of dry and warm weather.

V.E. and D.E.Bryagin was the first to use a lime-casein solution for consolidation of plaster ground in

1949 during restoration of the Assumption Cathedral of the Kremlin and the St Trinity Cathedral of the Troytsko-Sergievskaya Lavra. In the Assumption Cathedral ground is stabilized on the southern wall and vaults and arches adjoint to it. In the beginning part of plaster were fastened according traditional at that time methodology - by pouring with gypsum.

Twenty five years that passed since that time have shown that given method of stabilization with lime-casein solution proved very reliable. In the areas where it was used there is no loosening of ground up to date. This experience let also to conclude that stabilisation accordingly foregoing method hav no undesirable by effects. In streangthened areas there are no such phenomenons as colour alteration or efflorescence. Preservation of painting remains good. During strengthening of the Trinity Cathedral ground in stead of powdered casein a scimmed curds was used. Obtained results are quite the same that has been obtained in the Assumption Cathedral. In 1953 according to this methodology the consolidation of the southern wall of the Kremlin Archangels Cathedral was done. Now its preservation is good.

Using foregoing methods we have consolidated plaster grounds of following monuments: in 1957 of the

northern and western porches of the Church of the Ressurrection on the Wilds in Kostroma, in 1958-61 of all walls and vaults of the St Trinity in Nikhitniky in Moscow; in 1959 of Martiriyevskay parvis of Novgorod St Sophia Cathedral, in 1960-61 of dome-drum of the same Cathedral; in 1963-68 - all wall-paintings of Church of the Assumption in Meletovo near Pskov; in 1967 partially of dome and dome-drum of Church of the Transfiguration in Vyazma. In 1967-73 wall paintings of the Nativity Cathedral of the Savvino-Storojevsky Monastery near Zvenigorod have been consolidated. In 1965-1974 plasters of sanctuary and altare apse of the Smolensk Cathedral of Novodevichy Monaster was strengthened, in 1971-1973 plaster of dome-drum and of northern part of transept of the Spaso-Preobrazjensky (The Transfiguration of Redeemer) Cathedral of Miroz Monastery.

Presently the majority of Soviet restorers used this method. This system let to stabilize practically all kinds of ground dammage of oll paintings and as it was proved with experience gives garanties of longlasting good preservation of treated areas without any undesirable by-effects.

At the same time the method isn't expensive, simple

in handling, can be performed in any conditions and as the time has proved the quality of consolidation of gr ground by means of lime-casein solution is quite proportional to the quality of lime of which it was done. The seasoned and pure (without soluble salts) lime is, the stronger consolidation is.

Such is our concise summary of our practice of using for many years of lime-casein solution for consolidation of lime plaster ground of old wall paintings.

REMOVAL AND RESTORATION OF THE BICHVINTA MOSAIC

T.I. Todua

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The name "Bichvinta" originates from the Georgian word "pichvi" that means "a pine-tree". Bichvinta (or Pitsunda) is the cape grown with unique relic pines that have come down to us from the tertiary period.

In the last few years Bichvinta has become the best seaside resort on the entire Black Sea Coast. Here,in Bichvinta, the archaeologists of the History Institute of the Science Academy of the Georgian SSR uncovered the ruins of the antique town of Pitiunt.

In 1954 at a distance of 1 km from the seashore they excavated the temple with the mosaic floor. To continue excavations to study the lower cultural strata and to save the mosaic from sure destruction the Scientific Board of the Institute decided to remove the mosaic from the temple and to exhibit it in the Georgian State Museum of Fine Arts. The execution of this work was commissioned to us.

75/1/13-2

By its artistry, composition and execution technique the mosaic of the temple is the unique monument of decorative art of the 4th century.

The temple originally was a single-nave basilica with a large-spanned vault, a faceted apse and a spacious narthex. Later, after destruction, the temple was reconstructed into a three-nave basilica with columns dividing the naves. The apse and the narthex also underwent changes. Duuring the reconstruction the mosaic floor was partly cut out. That's why only separate fragments of the mosaic with a total area of 60 sq.m have come down to us.

The temple was situated under the ground in the pine grove where the soil was peaty and marshy. The floor of the temple was found at a depth of 2 m. Under the action of peat gases, moisture and fire the lime cubes of the mosaic and the mortar decomposed. Besides, some sections of the mosaic were destroyed by plant roots.

Before we got down to work we studied carefully the structure and condition of the mosaic foundation and composite materials.

The whole "antique town" was situated on the gravel sea terrace.

On the site where the temple was situated ground water appears at a depth of 1-1.5 m from the floor surface. To protect the temple from ground water vapours under the foundation of the mosaic the ancient builders made a waterproof layer of well-mixed clay. This layer was

40 cm thick. The next layer which was 20-30 cm thick consisted of cobbles mixed with mortar. The third layer was made of strong lime concrete 15 cm thick. The flattened surface of concrete was covered with three layers of mortar mixed with fine sand, broken ceramic pieces and charcoal. The thickness of these layers was 5, 3 and 1 cm respectively.

The above-mentioned layers made up the foundation about 1 m thick. Atop the foundation mosaic cubes were laid and fixed with pure mortar.

The mosaic was composed of broken pieces of the local stone and many-coloured sea pebbles. The palette consists of 12 colours of different hues.

The removal of the mosaic from the temple continued for three years. Work was done in summer and early autumn. The first thing we did was measuring and photographing the mosaic.

To protect the working site from bad weather we used mobile sheds. To remove water from the site we laid drainage pipes. After we cleared up the mosaic, we copied it with egg distemper on the cloth-backed paper. This is the best technique for the texture and colour of mosaics of this kind.

Our next step was to draw up a plan for cutting the mosaic into fragments. When marking dividing seams we took into consideration the lost parts of the mosaic. The size of fragments ranged from 1 to 2 sq.m depending upon the features of fragments and strength of their foundation.

Not to violate the arrangement of cubes over which the dividing seams were passing we made a

gypsum cast of each seam in the form of a strip 5 cm wide. Having turned over the gypsum cast, we separated each cube from its base and inserted it into its nest in the gypsum cast. Thus we obtained mosaic strips which from the reverse side were im-regnated with polybutylmethacrylate resin solution and covered with a waxy colophony paste with a gauze interlayer. Later on in the laboratory the gypsum casts were wetted, the mosaic strips were removed and put in their places on the panel on which all fragments and strips were assembled.

Fragments of the mosaic were removed accor-ding to the procedure described below. We started with fragments that were the nearest to the edge. By means of special cutters and scrapers we cut a groove around each fragment along the dividing seam that already had no mosaic cubes.

Having examined the condition of the mosaic base of the given fragment, we determined a cut plane and a groove depth. The surface of the mo-saic was cleaned, dried and covered with a prophy-lactic layer of gauze and thick paper with the help of the 10% joiner's glue.

By means of long scrapers we then scraped out mortar from the groove, laid a steel rope into the groove, put a polyethylene film over the prophylac-tic layer of gauze and paper.

A special frame that had the same size as the fragment was inserted into the groove slots. The frame had a cover made of wooden planks with clea-rances between them.

Everything was filled with a gypsum solution that spread over the entire fragment.

When gypsum hardened, we cut away the remainder of the base, turned over the frame with the fragment, filled it with saw-dust, put it into the wooden box and sent to the laboratory for further treatment.

In the laboratory we opened the box, removed gypsum amd mortar from the reverse side. Having reached the base of mosaic cubes we cleaned them with steel brushes. Loosened mortar between the cubes was strengthened by impregnation with a 10-15% solution of polybutylmethacrylate resin that has a relative viscosity index of 0.30 centipoise with respect to toluene. The solvent was xylol which has an ability to penetrate well into pores. The solution was applied with a brush 5-8 times. Such treatment increased the mortar strength 7-10 times.

After the fragment was treated with polybutylmethacrylate and dried, it was covered with a waxy colophony paste with the proportion 1:1. The paste layer was 1cm thick.

Thus the back side of the mosaic was reliably fixed almost up to the face side. Having removed the frame that was already unnecessary, we put over wax paper, 5 layers of ordinary paper, a panel; then we connected everything together and turned over. From the face side of the fragment we took off the cover of the box together with gypsum. Again we put over the panel, tied everything together,

turned over and removed the paper.

Eventually we got a mosaic layer glued onto the paper 1-1.5 cm thick and lying with its face side downwards on the flat panel.

Gradually mosaic fragments and strips were assembled on the panel into a whole composition.

Depending upon the composition size we made flat aluminium baths with sides corresponding to the thickness of the mosaic. To provide a good connection with the paste the bath bottom was notched. The bath was then placed over the assembled composition, slightly heated and pressed with the panel. Upon cooling, we removed the panel, laid a rigid band steel framework and turned everything over. The framework upon which the aluminium bath rested as a brazier was heated from below and then placed onto the cold panel and covered with another panel with a heavy weight. The mosaic was left to cool between the two panels.

In the end we obtained a thin even mosaic layer drowned in the paste on the aluminium sheet. We removed the paper, gauze, glue. We also removed from the mortar lime, soluble and insoluble salts that were detrimental for mosaic cubes. Next we did mechanical cleaning and washing without any chemical agents. As a result of such treatment the mosaic colours became originally bright.

We arranged our work in such a way that while we were treating the next lot of mosaic fragments, the already treated fragments were being washed with running water.

When all the above-described procedures were completed we secured aluminium sheets with mosaics on light rigid ribbed wooden frames. Now the mosaic was ready for an exhibition. It had an area of 10 sq.m and it can be easily lifted, put vertically or horizontally by two men. In the museum the mosaic is exhibited horizontally on the floor. In the repository it is kept in a vertical position.

The mosaic fragments were assembled so that to have the possibility to restore, if necessary, the mosaic shape as it was originally in the temple.

Similar work was fulfilled in the ruined palace in the village of Shukhuti (Western Georgia). Here we found an ante-room of the bath-house with geometric mosaics of the 6th century.

In the past few years we treated the mosaics removed from the verandah of the ancient house. These mosaics were executed with large-sized pebbles and broken ceramic pieces. They reproduced hunting scenes and mythological marine sujets. The field work was similar to that described above. The only difference was that these mosaics were fixed on the thin reinforced concrete base, allowing, if necessary, to install the mosaics in the place from where they were taken out.

TRAITEMENT DE CONSERVATION DES PEINTURES À LA COLLE DES MONUMENTS DE BOIS D'ARCHITECTURE DE L'UKRAINE OCCIDENTALE

URSS

L'Ukraine occidentale est riche en monuments d'architecture de bois, dont beaucoup sont ornés de peintures murales. Ces monuments sont datés des XVI^{e}-XVII^{e} siècles, tandis que les peintures intérieures - des XVII^{e}-XVIII^{e} siècles.

Le développement intense de l'architecture de l'Ukraine était suivi par un essor notable de l'art monumental et décoratif. Les peintures murales se sont répandues largement. On peut y voir, en comparaison avec des peintures murales russes, les nouvelles tendences, qui présentent dans les compositions des peintures ainsi que dans les principes de la corrélation de peintures et de l'architecture.

Les peintures murales des églises de bois, consistant de trois parties, - ce qui est typique pour l'Ukraine, - telles comme l'église de saint Esprit de Potelitch, et celles de saint Youri et d'Erection de la Croix à Drogobytch, sont des exemples les plus anciens de la peinture sur bois du milieu et de la deuxième moitié du XVII^{e} siècle, conservés en Ukraine.

Les peintures murales de l'église de bois de saint Esprit dans le village Potelitch de la région de Lvov présentent une grand intérêt comme un ensemble unique des années 20-40 du XVII^{e} siècle. Elles se sont conservées sur les murs sud, nord et partiellement ouest de la pièce centrale de l'église, ainsi que sur le mur sud de la partie supérieure. Les peintures murales de Potelitch, malgré toute son originalité, sont caracteristique pour l'art d'Ukraine de la fin du

XVI^e - du début du XVII^e siècles, et présentent les mêmes tendences d'idées et d'art. Malgré ses systèmes icônographiques traditionels, leur contenu et orientation portent un caractère démocratique.

La surface de bois des murs intérieurs de l'église n'était pas préparée (ou presque) pour recevoir la peinture; les peintres avaient seulement collé, sur les joints, une toile ou un papier et en se limitant de l'application d'une couche mince de levkas (l'enduit), de sorte de badigeonage à la chaux. La couche mince de la peinture laisse apparaître la coupe longitudinale des barres.

Les murs de l'église d'Erection de la Croix sont ornés de peintures de sujet et ornementales. Les peintures les plus précieuses sont celles qui se trouvent dans l'autel et se datent de l'époque de la construction de l'église - 1636. Les peintures se distinguent par un style monumental, un traitement généralisé de formes et une unité organique de toutes leurs parties; le coloris des peintures est assez discret, les images se caracterisent d'une esprit élévé.

Quant à l'intérieur de l'église de saint Youri, il est, en comparaison avec celui de l'église précédente, plus pittoresque, les espaces du nef et de la partie supérieur y se trouvent réunis avec le choeur d'une manière fantasque. Les tons bleus frais, rouges flamboyants et d'ocre s'harmonisent finement avec des teintes grise-cendrées, verte-claires et blanches-de perles.

Presque toutes les peintures murales des monuments d'architecture nécessitent un traitement de conservation immédiat. Les travaux de conservation de ces oeuvres d'art ont été commencés en 1968. Actuellement ces travaux sur la conservation des peintures murales dans l'église d'Erection de la Croix de Drogobytch et dans celle de saint Esprit de Potelitch sont terminés, tandis que dans l'église de saint Youri à Drogobytch ils se poursuivent encore. Les travaux s'effectuent par les restaurateurs de Kiev et de Lvov, qui sont consultés par collaborateurs du VCNILKR sur des problèmes de méthode.

Tous les travaux de conservation se sont faits à base d'experiments de laboratoire, réalisés sur les échantillons qui sont analogues des matériaux des monuments.

Le traitement a comporté les quatre étapes suivantes:

1) L'examen de l'état de l'oeuvre;

2) Les expérients de laboratoire executés sur l'échantillons;

3) Le choix des parties d'essai d'une oeuvre sur la place;

4) Les travaux de conservation sur la place.

Etat des peintures murales

L'examen de l'état de la peinture et du bois dans l'église d'Erection de la Croix de la ville Drogobytch a révélé des déteriorations principals du support (le bois) de la toile collée sur la préparation, de la préparation et de la couche picturale des peintures.

L'église est construite de rondins de pin, dont l'épaisseur se varie environ de 20 cm à 50 cm.

La surface intérieure des murs assez bien amenuisée a des nombreux défauts naturels (noeuds, fissures, trous de noeuds tombés). Le bois est affecté partiellement par des perce-bois et des champignons, surtout dans les zones humides: à côté des fenêtres, soit là où le toit avait laissé passer l'eau.

Tous les joints des poutres ainsi que les creux et les noeuds dans plusieurs endroits sont collés au moyen de la toile - pavoloka - qui est une toile de ménage de lin grossère.

Le support de bois et la toile (pavoloka) sont recouverts de préparation et de couche picturale. La préparation est appliquée en une couche très mince, et est composée de la craie et de la colle d'origine animale, contenante de la protéine. On l'avait appliqué à l'aide d'une brosse, à la façon d'un badigeonnage. La préparation est friable et faible.

La couche picturale des peintures est très mince, parfois transparente, par endroits couverte de craquelures à petit réseau. L'adhésion entre la couche picturale et la préparation ainsi qu'entre la préparation et le support est assez faible.

Dans les parties humides on peut voir les taches de rouille, imprégnant la couche picturale et la préparation et par endroits même le bois.

On observe l'écaillage de la couche picturale, le détachement de la couche picturale suivie de la préparation, des chutes. La couche picturale dans des parties isolées est bien conservée, mais a un aspect légèrement poudreux. La toile qui recouvre des fissures et joints est gauchi et partiellement perdue. Dans les endroits de détachement de la toile des murs la couche picturale est perdue avec la préparation.

Sur toute la surface des peintures il y a de petites fissures, d'endommagements mécaniques du bois, de la préparation et de la couche picturale.

La surface des peintures est couverte d'une couche de la poussière dense, incorporée dans la couche picturale.

Les couleurs de la peinture située sur les barres formant un certain angle avec les surfaces verticales, sont fortement changées, ce qui est dû à une couche de la poussière surtout dense et épaisse recouvrant la peinture.

Les analyses des échantillons de la couche picturale et de la préparation des peintures murales ont été effectués en laboratoire. L'analyse microchimique a identifié le liant de la couche picturale et de la préparation comme une protéine animale. La présence de jaune d'oeuf n'a pas été détectée.

La palette de couleurs des peintures est composée de pigments suivants: vert - le volconscoite, bleu - le smalt, rouge - le minium de plomb, noir - le charbon de bois, jaune - l'auripigment, le bleu clair organique.

Travaux expérimentaux.

Le travail effectué dans le laboratoire comprenait deux parties essentielles:

I. <u>La préparation des échantillons d'un bois</u>:

a) L'application d'un enduit sur la surface des échantillons;

b) L'application d'une couche picturale sur la surface d'enduit;

c) Le traitement de la surface de la couche picturale par divers composés;

d) La préparation des échantillons de la peinture sur pavoloka (la toile);

e) La préparation des échantillons présentant des lacunes de bois comblées.

II. <u>Les essais de la résistence des échantillons</u>:

a) aux changements de la température;

b) à perméabilité à la vapeur;

c) aux effets des températures basses;

d) au vieillissement;

e) aux agents biologiques.

<u>Préparation des échantillons</u>

Lors de la préparation des échantillons on a utilisé les matériaux, recommandés par VCNILKR pour la fixation de la peinture à la détrempe ainsi que matériaux traditionels, couramment employés dans la restauration des peintures.

Le choix de la composition de l'enduit et de la couche picturale ainsi que leurs testes ont été effectué sur l'échantillons, préparés en laboratoire. Les couches de l'enduit, des couleurs et du revêtement furent appliquées successivement sur les échantillons de bois mesurant de 4x1,5x15 cm.

<u>La composition des enduits</u>

1) craie + copolymère AV2EAH (4-5%);

2) craie + colle de poisson (4%).

Avant l'application de l'enduit les échantillons ont été collés par des composés qui étaient conforme au liant de l'enduit. Après le séchage de l'enduit, il a été couvert d'une couche picturale de composition suivante:

les pigments sec + le copolymère AV2EAH (2%);

les pigments sec + le copolymère AV2EAH dans le polyacrylamide.

On a utilisé les pigments suivants: les ocres - clair, rouge et d'or, terre de Sienne, outremer, oxyde de chrome, noir d'ivoire brûlé.

Une partie d'échantillons sont préparés de sorte qu'ils ont une toile de sac (pavoloka) collé sur un support de bois, sur laquelle on a appliqué l'enduit et la couche picturale.

Essais des échantillons

1) Les échantillons de laboratoire ont été essayé aux effets de changement des températures et d'humidité relative de l'air.

A cette fin on les a mis dans un réfrigérateur (à une température de -10°C), puis - dans une chambre humide, pour 24 heures (à une humidité relative de l'air de 97% et à une température de 20-22°C).

Le cycle de changements des températures et d'humidité relative fut répété 20 fois. Chaque fois, le cycle terminé, on examinait les échantillons en les comparant avec les résultats du cycle précédent. On a constaté, qu'après cinq cycles l'état des échantillons faits des polymères n'a pas changé; après dix cycles les échantillons en chêne n'ont pas également changé, tandis que ceux préparés en pin présentaient des microfissures.

En ce qui concerne les échantillons en colle de poisson, les microfissures y ont apparues déjà pendant septième cycle, et après 17 cycles nous avous observé le détachement de la couche picturale avec l'enduit, les boursouflures et l'écaillage.

Ainsi, on peut conclure que les échantillons préparés avec une dispersion d'eau du copolymère AV2EAH et AV2EAH dans le polyacrylamide, sont résistants aux changements des températures et d'humidité.

La colle de poisson est moins résistante aux changements des conditions de température et d'humidité.

En effet, pavoloka (la toile) recouverte de peinture et collée au moyen d'une colle de poisson, a été affectée par moisissures.

2) Les essais de la résistance des échantillons à la perméabilité à la vapeur furent effectués selon les méthodes élaborées par l'Institut de recherche d'Ukraine de la Modification du bois. Dans ce cas les échantillons à éprouver ont été traités de tous les côtés, à l'exception du côté couvert d'une couche picturale, par l'huile de lin cuite chaude et par le blanc de zinc à l'huile. L'humidité donc n'a pu pénétrer qu'à travers la surface recouverte de la couche picturale. On a mis les échantillons dans une chambre humide, à une humidité relative de 100%, jusqu'à leur saturation complète.

On a constaté que la perméabilité des échantillons, préparés avec l'emploi des polymères reste dans les même limites que celle des échantillons, faits avec la colle de poisson, c'est-à dire un échange d'air reste le même.

3) Pour les échantillons mis dans une chambre pour un vieillissement artificiel un regime suivant a été adopté: un traitement avec de l'eau de robinet et de l'air froid pendant 3 minutes; un chauffage par des rayons infrarouges jusqu'à une température de 70°C et traitement à l'air chaud pendant 6 minutes; une irradiation continue par des rayons ultraviolets à l'aide d'une lampe "ПРК-2". Le cycle est à répéter chaque 9 minutes.

Les résultats obtenus permettent de dire que les revêtements à base de AV2EAH dans le polyacrylamide et AV2EAH, suivi d'un traitement hydrophobe de la couche picturale par une résine silicone K-42, sont les plus résistants aux intempéries.

L'enduit sans revêtement est sujet à des déteriorations dans une plus grande mesure que celui recouvert d'une couche picturale.

Les mélanges contenant de la colle de poisson se sont révélés d'une résistance très faible. L'enduit et la couche picturale se sont trouvés enlevés complétement après 17 heures des essais. (Photo 3, 4).

4) Les essais de la résistance des pellicules de AV2EAH, de PAA et de la colle de poisson aux effets des agents biologiques ainsi que les enduits, préparés à base de cettes pellicules ont montré que des échantillons aux fixatifs AV2EAH possèdent d'une résistance biologique plus forte.

Travaux expérimentaux exécutés in situ

L'examen en laboratoire a permis de recommander, pour l'exécution des expériments in situ, des composés suivants:

Pour la fixation d'une couche d'enduit et de couleurs très mince - une dispersion d'eau du AV2EAH à 2%; pour une couche plus épaisse - la même dispersion à 3-4%; pour l'intégration de l'enduit - une dispersion d'eau du AV2EAH à 6%; pour le collage de pavoloka - celle à 10%; pour l'intégration des lacunes d'un bois - celle à 20%.

On n'a pas introduit le polyacrylamide dans le mélange de fixation, parce que les essais ont montré, qu'un composé à une dispersion d'eau du AV2EAH sans polyacrylamide donne presque les mêmes résultats que celui contenant le polyacrylamide, cependant ce dernier a une viscolité haute et instable, ce que pourrait empêcher une pénétration de la dispersion dans l'enduit.

On a choisi pour la consolidation expérimentale des peintures de l'église d'Erection de la Croix les six endroits, présantant les toutes sortes de déteriorations de la couche picturale, de l'enduit, de pavoloka et du bois.

Lors des expériments l'humidité relative de l'air à l'intérieur de l'église se variait de 82% à 90%, l'humidité absolute, détectée à l'aide d'un hydromètre ЭВ-2М - de 14% à 22%. Dans l'église les conditions de la circulation de l'air naturelle (ventilation) ont été crées pour assurer le séchage des murs dans les parties humides.

Au cours des travaux on a précisé certains procédés du traitement, les méthodes et régimes d'imprégnation de la couche picturale, les moyens d'introduction de la colle sous pavoloka et d'aplanissement de ses parties déformées, les procédés d'intégration des lacunes du bois et des vides, formés au-dessous de pavoloka à la suite du retrait du bois.

Lors de ces expériments certaines particularités des matières recommandées pour des travaux de restauration ont été révélées. La résine hydrophobe K-42 par exemple, appliquée au-dessus de la couche picturale, fait sa couleur plus vive. Pour cette raison, les parties, situées sous un certain angle vers la surface verticale, où la poussière fortement absorbée par la couche picturale a provoqué son termissement, ont été couvertes par une solution de résine K-42 dans le xylol à 6%; cette application a été répétée non moins de trois fois.

Le traitement de fixation des peintures dans l'église d'Erection de la Croix ont été terminé en 1972. A présent on n'observe aucuns changements de l'état de la peinture et du bois.

ASPECTS OF WALL-PAINTING IN POLYCHROME ARCHITECTURE: RELATIONS BETWEEN ITALY AND AUSTRIA FROM THE 15th TO THE 19th CENTURIES

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Abstract

Till nowadays we don't seem to have explored the neo-classic ideas of purism in architecture when regarding to material, colour or illusionistic painting. Therefore we must recall into our mind the close relationship between wallpainting and architectonic structure, a matter of course from antique times till the end of baroque style. To refind now how architecture in history was really looking like systematical examination of buildings with respect to surface structure, material and specific colour is necessary. A brief view is given on that methods. The importance of results at disposal finally is demonstrated by quite unknown connections between the developments of colour in architecture in Italy and the northern countries from the 15th to the 19th centuries.

Colour into architecture

Surface embellishment, imitation of expensive material, finted painting of structures and decorations but also weathering-protections (f.e. of sandstones) had been the main esthetical and practical functions from antique times to the end of 18th century. This can be clearly seen by consulting all different kinds of sources when dealing this problem: books in theory of architecture, models or sketches, bills and working notes, ancient views, house-names and other written traditions. But the most important of all we have to examine the buildings themselves which can be done for the best at restorations like we are used to do with polychromed sculptures or wall-paintings when they have been totally alterated at later times.

However the difference in dimension, material and composition up to weathering-conditions demands for a proper way to achieve reliable results. Consequently we propose as following a brief key for scientific examinations of that kind which has been used and developed by the author since 1967 in Austria. Similar methods are applied to in some other European countries like Germany East and West, Switzerland, Hungaria or Cechoslovakia. Because of the low international cooperation in that field up to now we hope to encourage further developments towards a more unified base that only would allow comparisons from ones to anothers results without any doubts due to different methods (1, 2).

Examination and restoration

1. Information is drawn from all monuments-offices in charge about the restoration program of the coming year. Thereafter examinations in mind are arranged before or at the beginning of works.

2. Copies available of plans, elevations or fotografs of the buildings in question are prepared or/and if possible fotogrammetric surveys (scale 1:50) are ordered to be executed.

3. Buildings history and datas of renovations or alterations known will be studied. Old collour-views are taken into comparison. But they only seldom show exact colours of a certain building, but can be useful ensuring and dating of later polychromies already found at the walls themselves.

4. Direct examination of the buildings surface from ladders, scaffolds or by means of an hydraulic lifted stage. All different levels, structures and heighths are to be proved. At buildings with courtyards, towers ecc. these parts have to be examined too with respect to different colours or different use of the same polychromy.
   Certain parts of an outdoor-facade normally offer the best results: beyond the cornice, in protected corners, beneath later window-frames or at ornaments and naturally better at sun-side than weather-side.

5. Documentation of all points examined to the elevations prepared. Designs and marks to different construction-materials that could be observed have to be added (stone, brick-work, wood, plaster, stucco ecc.)

6. Systematic stratigraphy of all layers of plaster and colours to be found including their characteristic surface-structures must follow. The results can be fixed by written records of layers, by graphic schemes or by fotografs of layer-"windows" made at the walls.

7. Important samples of material and paint-layers are at least taken from the walls to be preserved for primary documentation and also to serve for scientific analyses if wanted (Cross-sections, analyses of pigments, mediums, plaster-compounds ecc.).

Up to now we record results of about 60 buildings examined this way within the last 8 years (3). Naturally there is some priority given to buildings of higher artistic value (palaces, churches), but nevertheless also a number of simple houses of age which dominate our old cities have been taken into account. However when taking part of an ensemble a striking result of a single house must be carefully considered when reconstruction of its original or following polychromy is foreseen. Thus we first need total examination of the whole ensemble of a street or a place, a monastery ecc. to be able to decide the right period of polychromy for restoration with respect to the dominating majority of buildings in question (4).

Aspects of history of art

Every examination dealing with subjects of history need for comparison to be rightly qualified. We will know much more about our question if we have been able to compare results of serveral works from the same time and sometimes of the same architects. This had been the fact with the Carlone-group (6) of the 17th century and with J.L.Hildebrandt (1668-1745), who both came from Italy up to the north. In the meantime a comprehensive survey of all sources and relevant news to be found in ancient and modern literature has been set up referring only to German speaking countries (Germany, Austria, Svitzerland and formerly german colonised parts of East-European countries) from medevial times up to 1850 (7). There not only the phenomena of polychromed architectures are considered but also their function, iconology, materials and the part of patron, architect and craftsmen are tried to clarify for understanding properly our problem. For illustration of these dimensions let us call into mind only two cases for detailed information:
A journal reported in 1825 ("Flora", Munich) that "at Konstantinopel (Istanbul) may not the owner chose the colour of his house but has to respect the Turks will. Houses of Greeks and Armenians have to be brown or dark-red, that of Hebreans have to be black and only the Turks are allowed to take bright colours ...".
At Mannheim, Germany, a building-order of the town requested in 1738 that "houses within the streets may only be painted with red or white colour at a whole and may not painted one blue, the second red and so on."

Surely similar instructions do exist in serveral archives of other countries too, but no one has yet taken notice about. Art-historical monographs about single architects or buildings should also take care of the prior polychrome views of the works by studying the relevant documents.

Aspects of craftsmenship

Modern industry offers a lot of mostly synthetic products at a wide range of colours but technically like estetically well apted only for modern built houses. Consequently we have to select colours and binders that are visually similar to lime-bound white-washing as traditional and compatible to ancient plaster-material on the other hand. Because if ever possible nowadays restoration should conserve or reproduce the ancient plasters properties with its irregular levels and rich variations in surface structure (perfectly smoothed, brush-strips, covering of small holes or stone-mosaik a.s.o.).
To large extent we must try to reeducate the plasterer and other craftsmen devoted to buildings-conservation for the special plaster- and paintings-techniques to be found. At Vienna we proceed now initial works from the last war with a study-collection of different plasters, stucco and architectural polychromies that have been copied at a wall or in cases (5).

International cooperation will be very useful for this purpose because some mediterranean countries like Italy or Spain have preserved even more craftsmen-traditions alive than elsewhere.

Relations in architectural polychromy between Italy and Austria

From the 15th to 19th centuries we can observe several conformities of colours at buildings in both countries. In most of cases priority is to be found in the South, often due to north-italian architects and craftsmen traditional much working abroad since medevial times. But the lack of Italian research in that field till today offers only small possibilities to the foreigner to compare with Italian traditions. We will hope that a future collaboration could be stimulated which also should help to define better the origin, meaning and development of special italian terms like "macecco", "pastellone", "marmorino", "baciocc" ecc. that partly have become usual for Austrian plasterers language too.

15th and 16th centuries

Brickwork-constructions, glazed and/or painted or even imitations by painted brickwork-patterns are widely spread over Europe from 12th to 16th centuries. The importance of which show detailed investigations of the last few years (8).

From Piemont to Veneto medevial brick-architecture can frequently be found, the colour systems of which ought to be studied. At Venice and her surrounding a rhomboid distribution of red brickwork around white inner items and with a black one in the centre was quite common at the end of 15th up to the 16th century. Rhomboid red brick-decoration-patterns may first have been introduced at the Palazzo Ducales fronts (14th to 15th cent.) (Fig.1). A possible additional painting of brickwork there has vanished. But some decades later paintings of Carpaccio and Gentile Bellini and others (cf. miracles of St. Orsola at the Galleries of Venice Academy) up to Tizian (visitation at the temple, 1534, ibid.) we are ensured of that polychromy frequent to Venetian palaces of '400 and '500. At the inner nave-walls of Sto. Stefano at Venice (beginning of 15th cent.) identic painted brick-decoration is still conserved (Fig. 2). Similar brick-patterns may be found elsewhere in Italy (f.e. Rome, Villa di Papa Giulio, 1551-53, by Vignola) (Fig. 3), but certainly derived like the Venetian samples from oriental sources.

The famous glazed brick-monuments from early islamic cultures (f.e. Medrese at Kharghird, 1445 (9)) (Fig.4) demonstrate this oriental influence quite easily to understand when concerning the oriental trade and navigation of the Serenissima.

And now the relations northern to the alps, to Austria ? The small town of Wels in Upper-Austria, important of its trade between Italy and Germany, preserves some splendid houses of the 16th century, built in style of late Italian renaissance. This was as to demonstrate the humanistic education of their patrons. One of them, Johann Adam Freiherr von Hofmann von Grünpühel und Strechau, frequented the university of Padova in 1574, that of Bologna in 1579 (10). At this time, 1570/80, he renewed his house, Stadtplatz 23 (socalled of Salome Alt), which presentes besides a grey painted finted architecture of base and cornice a walldecoration painted with a brick-work-decoration similar to the above given examples from Venice (Fig. 5). Later on we find principly identic patterns at the mainfronts of the Arsenal-building at Vienna, finished 1856 by Theophil Hansen, with red and yellow burned bricks used (Fig. 6.)

Other traditions to be found in the north, the predomination of grey and black painted architecture from ca. 1550-1600 may be indirectly influenced by ideas of counter-riformation. This might be the fact with Cardinal Carlo Borromeo at Milan and his "instructiones", where yet no colour-details could be found. On the contrary a parish from Regensburg, who studied the ecclesiastic reforms at Milan, presents specific orders in his 1591 edited book: "Windows and doors have to be darkblack or ash-coloured with black underlining indoors likewise outside..." (11).

17th century

North-italian style in architecture was brought to Austria, Bavaria, Bohemia and other neighbouring countries by a crowd of native Italian architects, plasterers and stucco-workers. From documents we know that stucco-workers painted themselves their work, in 17th century not seldom by using coloured stucco-pastes. Similar traditions we find with plasters at walls of facades ("pastellone"). In 17th century we find predominant multicoloured polychromies varying from groundfloor to beletage, from front to the courtyard, indoors from sala terrena to salone. Huge amounts of pigments had been necessary for the wholly coloured plasters likewe could estimate about 5 tons of smalt to 20/30 tons of ironoxidered at the Esterhazy-palace at Eisenstadt, around 1660 (6). This multicoloured aspect had been enriched by very different surface-structures of plaster and stone-work. There existed several plaster-imitations "a la rustica", one by making holes, others by putting small stones, drosses, charcoals or glass-pieces to the wet plaster.

All these methods must be of antique age, coming from ancient mosaique-techniques that had been adopted for renaissance grotto-decorations and sometimes house-walls too (f.e. courtyard of the Casa Giannoni at Tivoli and some of the fantastic monuments in the Garden of the Villa d'Este, ca. 1570).

18th century

The architects who created the classic style of baroque in Austria, above all at Vienna, J.B.Fischer von Erlach and J.L.Hildebrandt, returned about 1690 from a longer stay in Italy, the one at the late Berninis workshop, the second with Carlo Fontana. The polychromy of their buildings is reduced to two light colours maximum. Pale milkblue to white showed Fischers Palais Trautson at Vienna, 1710, restored 1967/69 (12). The colours distribution changing from frontside (pilasters, windows jambs ecc. milkblue, walls white) to reverse composition in the courtyard. Several palaces built by Hildebrandt

could be proved up to now and always a light grey to order of pilasters, cornice, windows ecc. to a light yellow wall resulted. In documents the architect characterized these colours as soft ones ("lind"). The stucco-work inside was normally "ash-coloured" using the contemporary term too. Some buildings at Rome of the same time show similar polychromies. Fontanas Ospizio di San Michele, Cortile delle Zitelle 1710-15 (Provement of Rome-Centres courses 1974) or the models for the new sagresty of St. Peters 1715 at the Museo Petriano (13).

Surface chracteristics of this new "soft" classic polychromy are totally even walls made by means of smoothing the normal plaster with a 2-3 mm thick layer of lime and fine hairs mixed in between. Italian conservators visiting the restoration of the Belvedere in Vienna in 1947 called this "intonaco Palladiano" (14). The original yellowish colour upside they seemed to have overlooked too. However this "intonaco Palladiano" may be related with "marmorino", a plaster of white marble-powder, probably going back to Vitruv's plaster-rules. Maybe that italian colleagues know something more about origin, use and variations of this plaster-work employed till today in Venice.

A great number of italian plaster-workers during the 17th but mainly 18th century in northern countries spezialised to restoration of church-interiors and other buildings. They had been called "Weiß-Meister" or "Kunstweisser" and worked all over the country (f.e. Carlo Antonio Cerronetti from Graz the Cathedral of Salzburg in 1755). They primarily seem to have merely whitewashed the walls, but sometimes also cleaned stucco-decorations, restored wall-paintings like the above cited Cerronetti (15).

<u>19th century</u>

In 1836 italian methods of "marmorino" and stone-(dross- or glass-)mosaic to wallplaster - welcome to neoclassic ideas of time that estimated pure material without paint - have been reported and propagated by Ludwig Förster in his journal edited in Vienna (16). He became familiar with this technique at a journey to Venice and described "marmorino" made of marble-powder with lime, smoothed wet using soap-water, sometimes painted a fresco too and finally coated by a copal- or wax-varnish.

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(3) Samples are stored into plates of common isolating foam-material without any further preparation to allow all provements necessary further on.

(4) Everywhere in Middle-Europe we find today very busy painters-guilds and other professional or political groups fond of giving strong colours to old cities following only their modern naive taste. That will be well apted for humble villages like Burano near Venice but will give a quite contrary effect to ancient architecture of style. Another anti-historic movement for colour-activation to cities comes from the U.S.A. reducing architecture to serve for posters: H.Schmidt-Brümmer and F. Lee, Die bemalte Stadt (Du-Mont aktuell), Köln 1973

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Illustrations:

Fig. 1 Venice, Palazzo Ducale, 14/15th cent., facades

Fig. 1a Tizian, Presentation of the virgin at the temple, 1534 (Venice, Ex-Scuola della Carità, now Academy)

Fig. 2 Venice, Sto. Stefano, interior nave-walls, beg. 15th cent., painted decoration

Fig. 3 Rome, Villa di Papa Giulio, 1551-53, facade with rests of brick-decoration

Fig. 4 Kharghird, Medrese, 1445, facades with glazed brick-ornaments

Fig. 5 Wels, Hauptplatz 23 (house of socalled Sallome Alt), ca. 1570, with painted facade-decoration

Fig. 6 Vienna, Arsenal, finished 1856, facades with brick-decoration

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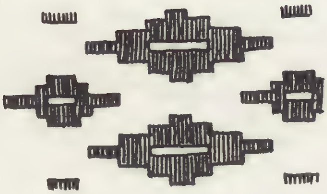

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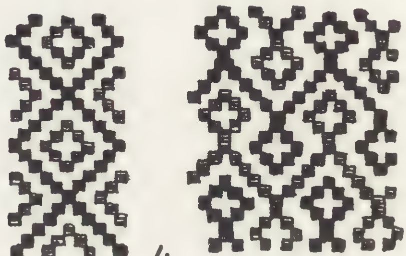

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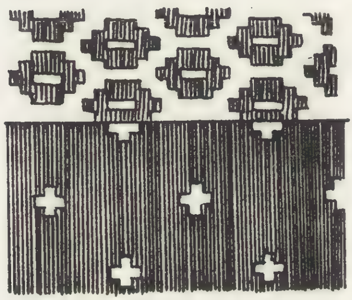

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white (figs.1,2,5) or ochre (figs.3,4,6)

red and lightred (fig.2)

black

blue

THE CONSERVATION OF JAVANESE SHADOW PUPPETS

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The use of shadow puppets has been recorded in Java for many centuries. They are still widely used today and play a significant role in Javanese social activities. One particularly fine collection formed in the mid 19th century has been in the possession of the British Museum for the past 120 years and has been the subject of a recent programme of conservation treatment.

These puppets, made from buffalo hide, were finely perforated before being decorated with rich painted designs and gold leaf. In consideration of their age they are in remarkably good condition partly because of the careful attention they have received whilst in store during that period and partly due to conservation treatment which is still in progress.

Although a very limited number of contemporary accounts of the manufacture of these shadow puppets are available, those which exist are much more concerned with character identification and puppetry techniques than with the technical processes of their manufacture, and it is only recently that systematic investigations necessary before embarking on restorative treatment have been undertaken.

The most likely method which was used to prepare the skin as the first stage of manufacture was by first stretching it over a frame or pegging it out to dry in the heat of the sun. It was then dampened and treated with lime to act as a depilant and at the same time to assist in the removal, by scraping, of the epidermis and the fatty substances of the adipose layer. The remaining corium was again dried by the same method until it conformed to the requirements of being a firm, transluscent skin which could be rubbed down with abrasive stones and leaves to bring it to an even thickness and a smooth finish on either side in readiness to receive the painted decoration at a later stage in production. The thickness of the skin, usually about 1 to 1.5mm was determined in relation to the size of the puppet

under construction.

The outline design and patterns for tooling were drawn directly on the surface or applied on a trace. Using a series of knives, chisels and punches designed for the purpose, the puppet was then cut out and perforated. Great care was paid to the sharpness of all cuts as, during performance, the puppets would be seen by an audience seated on either side of a transluscent viewing screen so arranged that some would see the painted puppet illuminated by direct light from a lamp, while the remainder would see its shadow silhouetted against a lighted screen.

The painted decoration appears to have been applied in a standard sequence. Both sides were painted identically which served to make the puppet opaque and, from the conservator's viewpoint, had the added quality of considerably reducing its vulnerability to bacteriological attack and other natural forms of deterioration by acting as a seal to the whole surface.

Although complete results of examination of the paint layers and their technical application, etc., are not available at the time of writing, certain details collected from various sources would appear to be confirmed by findings so far obtained. The basic palette was no more than the three primaries, red, blue and yellow, plus black and white, the red being vermillion, blue-indigo, yellow-orpiment, black was normally lamp black, and white was prepared from bone ash. Fish glue (Anour Lempeng) and the ash from burned rattan (londo-djangkang) used as a lye were the other normal ingredients. Evidence suggests that egg, possibly whole egg, was sometimes used, and traces of a resin of the dammar type are also apparent. The latter may have been used as a surface coating which has largely disappeared with age and handling. Before the decorative patterns and gold leaf were applied, the puppet, including edges created by cuts and perforations was prepared with a ground made from white bone ash, fish glue and burned rattan. The artist applied his paint in such a way that primary colours were never adjacent, secondary colours would always separate them. The lighter colour gradation was normally achieved by adding appropriate quantities of white to the standard colours but darker tones were effected by cross hatching and line drawing techniques applied after the paint had dried.

When the decoration was completed, arms were attached to the body of the puppet by pivots usually of bone. Rods to be used as manipulating sticks were prepared from finely worked horn which, when finished, had the appearance of being turned. The lower part was of the greatest diameter and formed the hand grip. The remainder of the rod tapered to a thickness of about 2mm at its extreme end. From a point just above the hand grip, the rod was split longitudinally and by a process of heating and bending it

was shaped to a predetermined design so that when the puppet was placed between the two halves of the rod it would assume the correct position to be firmly tied and provide good balanced handling while in use.

Fortunately, skin prepared as described above is normally very durable, a quality reflected in the generally good condition of most of the puppets, but some deterioration had occurred. There was evidence of embrittlement and some slight contraction. Hydrothermal shrinkage is no doubt responsible for the cockling where it had occurred and this, in turn, caused flaking and paint loss, but while it probably accounts for the more substantial areas of damage, flaking and loss has also occurred to puppets which have retained their flatness. This is the inevitable result of normal deterioration processes plus the fact that in use and in storage the animated parts of the puppets as well as the irregular projections of the features,

e.g. the accentuated form of hair styling, protrusion of noses and krises, etc., have rubbed together or intertwined causing them to become misshapen. In addition, the colours of the painted decoration had become somewhat subdued by the presence of dirt.

Some of the manipulating rods had broken and parts or complete rods were missing from a few puppets.

As there are over 400 skin puppets in the collection, any restorative treatment has to be considered as a long term project and accordingly a programme was drawn up on the following lines.

Firstly, the puppets were cleaned to remove surface dirt and deposits by the careful application of small swabs of cotton wool moistened with a non-ionic detergent (Lissapol N). After experimentation with a series of cleaning agents this was found to be the most effective method of cleaning and was believed to have involved the least risk, but because of the nature of the paint layer, prolonged cleaning with water could have been harmful. In order to obviate any loss of surface pigments stubborn blemishes were removed with potassium oleate soap (Vulpex) in white spirit (approx 2½%) and other more active cleaning agents were used occasionally when the special circumstances demanded.

The second step in the treatment was to relay flaking or blistered paint and gold leaf. This was accomplished with a P.V.A. emulsion adhesive (Texicote 03.010).

It was important that the paint and gold leaf was firmly attached before commencing the third step which was to relax the skin with a leather dressing. Failure to do so would have created a difficult and unnecessary complication for the conservator since the dressing is greasy and if applied to flakes or blisters prior to their being reattached will lay them temporarily, but as the dressing dries the flakes which will by then have absorbed a quantity of the dressing will begin to peel away from the skin which also has a greasy surface and a critical degreasing operation of both surfaces will have to be effected before re-adhesion can be undertaken.

The dressing originally used to relax the skin was British Museum Leather Dressing consisting of:-

200 gms	anhydrous lanolin
15 gms	beeswax
30 ml	cedarwood oil
350 ml	hexane

This, although effective as a dressing, was found to leave the surface of the puppet in a tacky condition for several months. Dressing with Pliantine, which has the same formula as B.M.L.D. except that it contains no beeswax, was found to be more suitable. Excess dressing was not removed from the puppet for several months,

and to this effect the many perforations acted as retainers and offered scope for good penetration into the skin.

The fourth step was to remove the surplus Pliantine with a suitable solvent - hexane or petroleum ether, and to mechanically clear the perforations with a probe. For the latter operation a finely worked ivory point was found to be more suitable than a wooden one if only because wood is likely to break more easily and needs constant replacement.

At this stage it was noticeable that there had been a slight darkening of the colours of the puppets as a result of impregnation, but the dressing gradually dried from the surface and the colours returned to normal.

The fifth step was to flatten those parts of the puppets which had become misshapen either due to cockling or their having been folded. To deal with large areas of distortion it was necessary to remove the manipulating rods so that (a) the skin could be laid flat and (b) to relieve the tensions to which the tied areas of the puppet had been subjected under contraction while the outer edges of the skin were free to react normally.

The puppet was then placed in a humidified atmosphere overnight (R.H. approx 65%) to further relax the skin. It was next placed between two flat surfaces protected by resist papers and light pressure was exerted. Pressure was increased at regular daily intervals for three or four days until inspection showed little or no puckering remained. The puppet was released from pressures and the manipulating rods replaced.

At this point the restoration of missing paint was possible.

Dependant upon the condition of the puppets it had to be decided if a protective surface coating was desirable. Two materials were selected for this purpose, they were:- for puppets where flaking had not occurred but the surface had a powdery consistency, a soluble nylon polymer (Calaton B.) dissolved in I.M.S. (3%) and those which had previously been treated against flaking with Texicote 03.010, the same material, (Texicote) was used for consolidation.

Finally, the broken horn rods were repaired with epoxy resin adhesives, and replacement rods or replacement parts were cast in moulds of silicone rubber from identical or very similar original rods in polyester resin reinforced with glass fibre threads.

To minimise the amount of handling of the stored puppets, special mobile storage screens have been constructed having a wooden framework approx 2 metres square supported by a central batten. Each frame is covered with a heavy, transluscent, plastic sheet and is supported on an overhead rail at the top and located on a U shaped track. Frames are mounted on parallel tracks in groups so that each individual frame may be pulled out and inspected without interference to others.

Puppets may be tied to the plastic sheeting for long term storage and, under normal room lighting, examined or photographed untouched. A bank of low level lights mounted on a wall in parallel to the movement of the frames provides back illumination for examination or photography of the puppets in shadow.

Abstract

This paper is concerned with a collection of Javanese animated skin puppets used in shadow play during the first half of the 18th century, but the author suggests that its content is relevant to a wide variety of similar objects.

Reference is made to probable techniques and materials used in manufacture, and a method of restorative treatment which has been developed in the British Museum is discussed. A brief account is also given of a storage method which, allied to the conservation treatment, should eliminate the main sources of deterioration in future years.

Acknowledgements I would like to thank the Scientific Department of the National Gallery for their very valuable help in analytical works.

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J.W. Waterer ' Leather objects'
Textile Conservation, IIC., London 1972

J.W. Waterer ' Conservation and Restoration of Leather', IIC, London 1972

R.L. Mellema ' Wayang Puppets'
Koninklijk Inst. voor de Tropen Amsterdam 1954

J. Scott-Kemball 'Javanese Shadow Puppets' British Museum, London 1972

Supplies

B.M. Leather Dressing is available from	Hopkin & William Ltd., Chadwell Heath, Essex.
Pliantine	A. Rich & Partners Ltd 41 Mt Pleasant Drive Belper, Derbyshire
Vulpex and Calaton B	Picreator Enterprises Ltd 44 Park View Gardens Hendon, London NW4
Texicote	Scott Bader & Co Ltd Wollaston, Welling- borough, Nothants

Lissapol N. is supplied by I.C.I. Ltd.

A SURVEY OF METHODS OF STORAGE OF ETHNOGRAPHICAL COLLECTIONS

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Preliminary report on a survey of storage methods used by museums with major ethnographical collections. The survey of the United Kingdom is complete, while that of North America and Europe is incomplete and is continuing. The survey so far shows that museums have similar policies with regard to storage, and most institutions are following one or other of two basic storage methods - either open racking with the artifacts uncovered, bagged or boxed, or closed cupboards containing drawers, trays or shelves - with specially designed units for weapons, costume and textiles, and very large artifacts.

Summary of basic storage methods

(Listed by individual museum in the attached Appendix).

1. Open racks

This is by far the most widely-used method of storage for ethnographic materials, as can be seen from the individual museum reports (see Appendix). Artifacts are simply placed upon the racks uncovered, or within plastic bags, or boxes. Cardboard or wooden boxes are frequently used in conjunction with open racking, and are sometimes designed on a standard modular system so that smaller boxes will fit into larger ones.

The advantages of open racking is that it is economic, and easily assembled, if necessary by museum staff. The disadvantages are the problem of dust, if the storage area is not air-conditioned, and if most artifacts are boxed, inspection becomes a slow and laborious process. Although most museums attach lists and sometimes photographs, to the boxes to identify the contents.

2. Closed cabinets or cupboards

Fewer museums use a system of closing cupboards, although those that do are satisfied with this method. Cupboards may have solid or glazed doors, and can incorporate a variety of interchangeable fittings, such as shelves, trays and drawers, which may be adjusted to accommodate the artifacts and to make the best use of the space available. The advantages are that once a cupboard is opened it is generally easy to inspect the artifacts therein, it is possible to incorporate adjustable fittings such as shelving, trays and drawers, and dust is less of a problem. Also locking doors provide extra security. The disadvantages

are that cupboards are expensive, and as they are complicated to make it is usually preferable to obtain commercially supplied units.

Sliding cupboards that run along a track in the floor are a very good method of saving space in a limited storage area. They are used extensively by libraries, but although many museum curators know about the potential of this method, most seem to reject it because of the fear of possible damage to artifacts by vibration as the cupboards are moved. Only two of the museums so far surveyed use sliding cupboards, and a third intends installing a system of this type in the near future.

3. Special systems for certain categories of artifacts

Nearly all museums with ethnographical collections devise special solutions for the storage of three major categories of artifacts - weapons, costume and textiles, and very large awkward or fragile items. The choice of any particular solution is largely pragmatic, depending upon the requirements of individual artifacts and the resources available to the museum, but nonetheless the methods used by different museums do broadly correspond:

(a) Weapons

The most widespread method is to store weapons individually, either secured to frames covered with pegboard, or with metal mesh (sometimes plastic-coated), or supported upright within a stand.

(b) Costume and Textiles

Many museums roll larger textiles and store smaller ones flat in drawers or on trays. Costume is also sometimes stored flat, but because space is generally at a premium most institutions hang costumes, usually within cupboards.

(c) Large objects

Storage methods for large artifacts, such as canoes, drums, and items of furniture, are pragmatic and depend upon the requirements of the individual specimen.

Classification of Artifacts

Most museums endeavour to store ethnographic collections according to a geographical system which subdivides into tribes and regions and then type of artifact. Nearly all museums have some sort of retrieval system to facilitate the location of particular objects.

Physical Relationship of Stores to Museum

An increasing number of museums are having to store their reserves away from the site of the museum building, and often at some distance. There are obvious advantages in having the reserve collection in the same building as the exhibited artifacts, but sometimes the decision to separate the two has to be made so that the reserves may be properly stored and conserved.

Conclusion

Museums are aiming for storage that provides the best possible conditions for preserving their collections while at the same time allowing them to be used. The achievement of these ideals requires space, staff and finance far beyond the resources of most institutions. Nonetheless many museums are developing successful solutions to the peculiar problems imposed by ethnographical collections, and it is interesting to note that much ethnographical storage utilises broadly similar pragmatic methods.

Appendix

List of individual museums giving storage methods (incomplete)
/V/ = visited
/P.C./ = personal communication

United Kingdom

1. Bristol City Museum /P.C./
In process of installing a system of racks with most artifacts contained in cardboard boxes. Below racks will be cabinets for smaller items. Specially designed units are planned for weapons. Large textiles are on rollers. The reserve collection is arranged on a regional basis, and there is a location/retrieval system.

2. British Museum, Department of Ethnography, Orsman's Road Stores, London /V/
The reserve collections of the Museum of Mankind (with the exception of costume and textiles, which are kept at the museum building in Burlington Gardens because of high demand) are in newly designed storage in a converted warehouse. Metal racking is used in conjunction with wooden boxes. The standard unit is a 4 cu. ft. box measuring 25" x 23½" x 12¼". Especially fragile or awkward items have specially designed boxes with padded interior supports. The move out of the main British Museum building, which entailed separating the reserves from the Department's new building, was the main reason for adopting a box system because the artifacts had to be moved safely. Very large items and weapons are stored separately, otherwise the racks are arranged on a regional and tribal basis. The storage areas are air conditioned, and there is a location/retrieval system.

3. Cambridge University Museum of Archaeology and Ethnology /P.C./
A major rehousing plan for part of the ethnographic collections at a site away from the museum is beginning. It is planned to use a system of metal racking with boxes, similar to that at the British Museum, and organised on a regional basis. There will be work areas for visiting researchers and a conservation workshop attached to the storage area.

4. Liverpool City Museum /V/
The store is at a site away from the museum, and consists of open racking with standard wooden boxes. Weapons are hung on wire frames on the walls. Textiles are rolled in boxes and costumes are hung. There is no air conditioning and staff find that dust is a problem.

5. Pitt Rivers Museum, University of Oxford /V/
Part of the reserve collection is stored in a converted warehouse at a site away from the museum. The storage consists of open

racking with cardboard boxes. Weapons are hung. Costumes are stored on hangars or flat in drawers and textiles are rolled. The rest of the collection is stored by type in drawers beneath the display cases in the museum.

6. Horniman Museum and Library, London /V/
The major part of the reserve collection is stored away from the museum. Within the museum some artifacts are stored in sliding cupboards.

7. Royal Scottish Museum, Edinburgh /V/
The reserves are stored within the museum in locking wooden cupboards incorporating interchangeable plastic trays and wooden shelving. Weapons are fastened to sliding racks within cupboards and costumes hung in cupboards. The storage is arranged by region and there is a retrieval system. Air conditioning is being installed.

8. Manchester University Museum /V/
The reserve collections are stored within the museum in glass fronted, dust-proofed wooden cupboards with adjustable shelving. There are special units for weapons and large or awkward objects, (the costume collection was transferred to the Whitworth Art Gallery for conservation reasons). Classification is regional and there is a retrieval system.

North America

9. Smithsonian /V/
Open metal racking with the artifacts in plastic bags, or within wooden boxes sliding on wooden runners within racking. The stores are arranged by region and are air conditioned. Storage is within the main museum building.

10. McCord Museum, Montreal /V/
Reserves are stored within the museum on open metal racking. Most artifacts are uncovered and some are in plastic bags. Weapons are hung on metal mesh frames on the walls. The stores are arranged typologically, and are air conditioned.

11. National Museum of Man, Ottawa /V/
Reserves are stored in a warehouse away from the museum building. System of open metal racking with artifacts uncovered or in plastic bags. Costumes are stored flat in wooden drawers. Large objects such as canoes have specially designed supports.

12. Milwaukee Public Museum /V/
Storage is within the museum building on open metal racking with wooden trays sliding on runners. Artifacts are contained within cardboard boxes on the trays. There is some wooden and metal shelving for larger specimens. Fur costumes in closing cupboards. The reserves are arranged regionally and there is a retrieval system. The storage area is air conditioned.

Europe

13. Museum voor Lande-en-Volkenkunde, Rotterdam [V]
The reserve collections are stored away from the museum and the storage utilises the sliding cupboard system, classified by region.

14. Übersee-Museum, Bremen [P.C.]
Planning a new storage system using sliding cupboards for as much of the collection as possible, including ceramics and metalwork, which will be secured by special fittings within the cupboards. Costumes are hung on moveable metal frames on wheels.

A HAND HELD MICROSCOPE FOR THE EXAMINATION OF PICTURES

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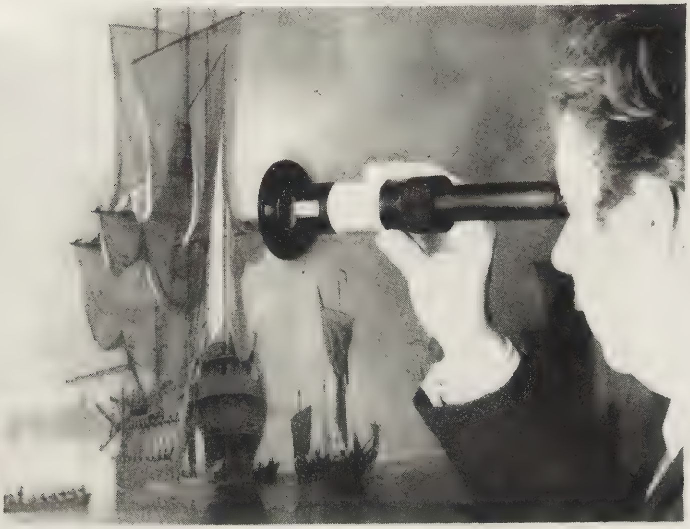


ABSTRACT

A hand-held pillar microscope giving magnifications from 16x to 250x has been in regular use for many years in the Picture Restoration Department of the National Maritime Museum, London. It offers an advantage over the conventional microscope for local examinations in that it can be placed safely on the surface of the picture and provide rapid high quality visual or photographic information.

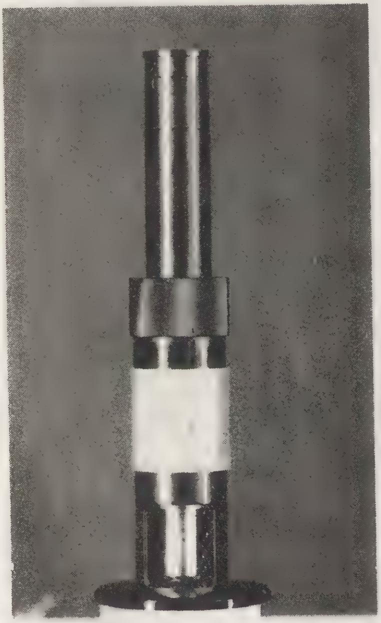
75/4/1-2

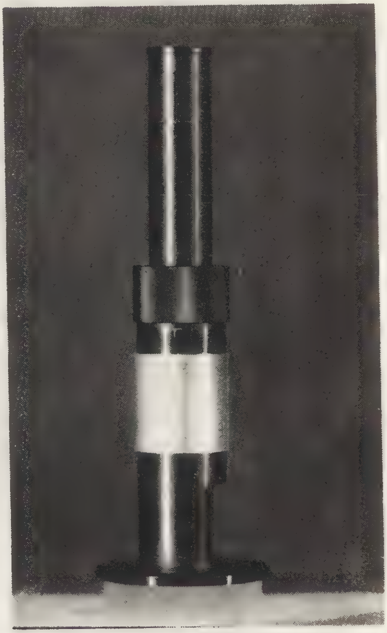
THE MICROSCOPE

In 1962 I put together for the first time the basic components of a small portable microscope with extremely high resolution. This was to prove to be an invaluable aid for the examination of paintings, drawings and graphic art.

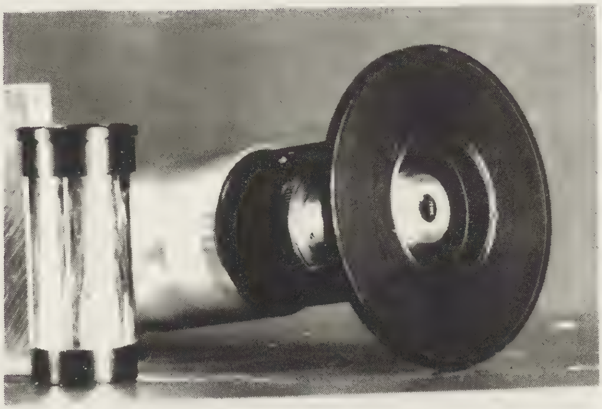
Even at today's inflationary prices, it presents a low cost, lightweight item, easily adapted to the uses of individual restorers in studios or museum laboratories, or out on location.

Standing less than 23 cm (9") high, it weighs about 300 gms (under 1 lb) including all components.





One of the most valuable aids that the restorer can use for examination of paintings, prints and drawings is the hand held pillar microscope. It can be used to observe the pigment conformation of the painted surface, paint structures and pigments, micro cross sections, macro and micro crackle patterns. Its range of magnification from 16 times to 250 times allows it to be used to solve a wide variety of problems concerned with the conservation of pictures. The instrument is composed of a microscope tube set into a further focussing tube standing on a flanged base plate with a circular opening. The microscope is focussed by means of a broad knurled ring, the lower part of the tubular base has a cutaway section allowing light to enter the circular opening. I have adapted a printers offset magnifier (Zeiss Jena Type 568002F) to form the body of our hand microscope. The eyepiece in use is a Periplan GF10X, (field of view in eyepiece 18 mm), made by Leitz of Wetzlar. Three objectives are in current use. These are the Plano 4/0.10 (Leitz), the Plano 10/0.25 (Leitz) and a recently introduced microzoom objective made by Carl Zeiss of Oberkochen Plano 1.6/0,03 to 5/0,1. This objective suits the 160 mm tube length but adjustment has to be made for the two Leitz objectives increasing the existing tube length by 10 mm to 170 mm. Further more high powered objectives can be used but those listed give the most convenient use combining adequate depth and flatness of field necessary for the examination of the surface of paintings and drawings.



The pillar microscope is held in direct contact with the vertical painting or with an intermediate cork support painted matt black which rests on the surface of the horizontal painting and remains motionless whilst the microscope can be moved across its upper surface. The $7\frac{1}{2}$ cm (3") outer diameter of the cork ring with a circular opening diameter $4\frac{1}{2}$ cm (1-5/8") allows a microscope movement of roughly $\frac{1}{2}$" in any direction from the centre. This area of mobility at magnifications of about 100x is of great advantage when one is seeking a representative area to examine or record. Melinex or Mylar film can be placed below the circular cork support giving further protection to the painting or the drawing.

ILLUMINATION

Good daylight provides adequate illumination at the lower magnification range, but further illumination becomes necessary when going over about 20 or 30x magnification. A useful cool light source is provided by the quartz halogen lamp, the Daray 1300. When a more directional light source is needed for higher intensity illumination or oblique lighting from a more distant position, the Concord Lytelab offers a light source with adequate cooling facilities. It incorporates an iris head diaphragm which gives infinitely variable circular beam control. It should be used with a parabolic reflector and a bi-convex lens to give a sharp edged beam, and these fittings are standard. This light provides the best type of illumination for the critical examination of signatures.

The Zeiss microzoom objective set at 1.6x allows observations of a general character to be made in a medium low range of magnification (16x) which is very difficult to achieve with other lenses. The microzoom objective provides variable magnification between 16x to 50x. Its good depth of field is useful where the thickness of the paint surface usually creates focussing difficulties. Slightly higher resolution is achieved at the expense of some depth of field by the use of the Leitz Plano 4.0x, but if the surface is sufficiently flat, this objective will offer more detailed information.

The Plano 10/0.25 has been found in practice to be the most useful objective. It provides about 100x magnification and is best suited for examination of micro cross sections, pigment conformation in paints, grain counts in drawings and rapid general observation of flat objects. The 12.5x apochromatic objective made by Leitz provides higher magnification with

improved resolution and is useful in the examination of pigment agregates in micro cross sections or when the paint surface is extremely flat.

This microscope can be used to make examinations in transmitted light eg drawings over a light box, in incident light eg normal surface examination of paintings, or in oblique light where the surface structure of the painting or drawing is accentuated. The raking light in this case enters through a cut-away section in the cork stand. All these examinations can be recorded photographically in black and white or colour film by the use of a microscope camera. We use a Leitz Makam camera for this purpose. It gives a 9 x 12 cm format and is provided with a focussing eyepiece with graticule. Both the Daray and the Lytelab lamps provide sufficient illumination for photographs to be made.

THE EXAMINATION OF DRAWINGS

The value of having before and after examination photographs made during the conservation of prints and drawings is often overlooked although fundamental changes can happen to the tonality of the drawing or to the structure of the paper during conservation treatment. It is essential that the restorer is aware of the changes which can happen during the process of conservation and the hand microscope provides a means of recording these possible alterations. Life size photographs of the drawing before and after restoration usually fail to show sufficiently clearly changes in tonality of paper or the pigmented areas to have any relevance as a technical record. For example the texture of the paper might change from being medium rough to comparatively smooth with little noticeable effect in the photographic records.

With the use of this microscope, however, these problems are largely overcome. The pigment forming the drawing can be examined both in incident and in transmitted light whilst the original texture of the paper can be usefully examined and recorded under the low powers of magnification (16x) using a set repeatable position for the oblique raking light source. Still lower powers are, however, desirable and macro lenses attached to a copying camera are better for this purpose.

In pigment particle count examinations, the drawing or water colour is placed on the light box and is covered with a protective glass or film of clear Melinex. The cork support is put over the area to be examined. The microscope is placed over the cork ring and moved backwards and forwards. When a suitable area is found where the distribution of the pigment particles can be observed, it is recorded photographically. Should there be no change in the distribution or the number of pigment particles after the restoration has been completed, then the drawing will not have changed materially in terms of quantity of pigment used.

For comparative purposes it is naturally essential that the same area should be examined before and after treatment and it is sometimes useful to have a transparent grid overlay placed between the microscope and the drawing to locate the area being studied. Particle count photomicrographs should always be made using transmitted light. The changes occurring to the original drawing by the attachment of new supporting papers makes little difference to the registering of the pigment particle conformation in the subsequent photographs, as images from the supporting papers lie outside the field of resolution.

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THE EXAMINATION OF MICRO CROSS SECTIONS.

Micro cross sections of paint layers embedded in clear resin and polished can be studied by means of the hand microscope and the high resolution one normally associates with a laboratory microscope, can be matched if the specimen has been suitably treated and the light is sufficiently controlled. The Concord Lytelab should be brought close to the microscope and a small ground glass diffuser placed behind the focussing lens. The iris should be stopped down to the smallest aperture permissible for lighting the section. This light provides adequate illumination for magnifications of about 100 times. The Plano 10/0.25 objective is normally used.

Stages of preparation for micro cross section examination -

1. The examination must be carried out on a strong stable bench. Laboratory bench tops are suitable for this purpose.

2. Take a piece of black plasticine roughly 1 inch cube. Press this firmly onto the bench top, giving some degree of adhesion. Take a steel ring 2½ inches in diameter (external), 2 inches in diameter (internal), 1 inch high, the upper and lower surfaces to be ground parallel and be flat and accurate. Place this ring over the piece of plasticine leaving space between the plasticine and the inner wall.

3. Take the micro cross section embedded in its block of resin and press this onto the top of the black plasticine, leaving the top surface of the specimen slightly above the level of the surrounding metal ring.

4. Take a small piece of thick plate glass and place this gently

on top of the section, press firmly down towards the ring. When the plate glass touches the walls of the ring, the section will be level and ready for examination. Remove the plate glass and place the microscope into position, the bottom flange resting on the metal ring.

5. Bring the lamp into position shining the beam through the opening on the side of the hand microscope, adjust the iris reducing the size of the beam of light and focus the hand microscope in the normal way.

The microscope can now move across the area of the cross section by moving the lower steel ring or the flange of the microscope against the upper surface of the ring. These two movements are very useful in arriving at the precise location required for the examination of the section and correspond to the movements normally found on a microscope stage. Photographic recording can be carried out as previously described. Exposures should be controlled by the switching on and off of the microscope light, to minimise unnecessary movement.

This microscope has proved invaluable to myself and my staff over the years. It is an answer to many restorers' examination problems, especially in connection with micro work on large paintings and in awkward situations where a normal microscope cannot be set up. I shall show examples of its photographic capabilities during the working group session.

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DETAILS OF SUPPLIERS

Body: Aufsetzmikroskop für Durch- und Auflicht.
Bestellnummer 568002F. Carl Zeiss, Jena.

Objectives: Plano Pl.4/0.10, focal length 41.5mm, 170/-, free working distance 15mm. Ernst Leitz, GMBH, Wetzlar, W Germany.

Plano Pl.10/0.25, focal length 17.9mm, 170/-, free working distance 7.5mm. Ernst Leitz, GMBH, Wetzlar, W Germany.

Plano 1.6/0.02 - 5/0.1, Microzoom, 160/-, Carl Zeiss, Oberkochen, W Germany.

Attachment camera: Makam, 9x12 cm format, Ernst Leitz, Wetzlar.

Light sources: Daray 1300 Precision light + transformer unit, Lewis Spring Products Ltd, Leighton Buzzard, Bedfordshire, UK.

Lytelab Lighting Unit & transformer, Concord Lighting International Ltd, 241 City Rd, London EC1P 1ET, UK.

ANALYSIS OF $^{35}SO_2/CaCO_3$ REACTION ON THE MARBLE SURFACES OF VENICE BUILDINGS BY RADIOCHEMICAL AND OPTICAL METHODS

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Abstract

On the basis of a theoretical model suggested by O.Vittori and his coworkers, the oxidation of SO_2 in $CaSO_4$ on Venice marble surfaces has been investigated by nondestructive techniques (radiotracers and optical methods).

A climatic chamber has been build up to reproduce the Venice environmental conditions.

Samples of Venice marble have been subjected in the chamber to cycles of heating and cooling in $^{35}SO_2$ atmosphere with high relative humidity. Other samples have been taken in wet conditions to compare them to the previous ones.

Some sample surfaces were partially covered by Venice air particles and $FeCl_2$ as SO_2 oxydation catalysers.

This kind of "stone sickness", that is the SO_2 transformation in stable $CaSO_4$, seems mainly to be caused by the pollution particles as well as the effect of atmospheric conditions: heating and cooling of Venice stone and marble surfaces.

INTRODUCTION

In a previous communication (Vittori)[1] a modified theory of SO_2 attack on the marble surfaces has been discussed.

The theoretical model suggests a H_2SO_4 attack mechanism on marbles not only involving the SO_2 concentration but mainly the behaviour of the transportation of sulphur compounds from the air on the surfaces.

It is assumed that the SO_2 oxydation occurs in the liquid con-

densed phase on the marble surfaces and it is catalysed by metal particles as suggested from Junge and Ryan[2]. After the water layer evaporation the $CaSO_4$ precipitates substituting natural $CaCO_3$.

In this matter the attack is due to the condensation evaporation cycle caused by the solar radion on the marble surfaces.

On the basis of this theory the transormation of SO_2 in SO_4^{--} on Venice marble surfaces has been investigated by radiotracers and physical methods, nondestructive techniques, in a special chamber reproducing the Venice environmental conditions.

EXPERIMENTAL

A special chamber shown in Fig.1 has been built up to reproduce the climatic and pollution conditions of Venice atmosphere.

The total volume of the climatic chamber is $1\ m^3$.

Particular care has been taken in sealing the inside toxic and radioactive gases.

a) Climatic parameters

The most important physical parameters considered in the chamber are: temperature (18°C), relative humidity, SO_2 concentration (usually 3 ppm), and air particles.
The humidity is controlled by a psycrometric moist meter which operates two sprayers of water, stored in the bottom, realizing a closed system. Metallic particles are present in the water and then they are vaporized together with the water itself.
The SO_2 concentration is checked by a Beckmann 906A autoanalyzer. A part of SO_2 is depleted by the analyzer, another part by solution in the bulk water. Infact in one week the SO_2 concentration in the condensed water is 3 mM/1.
The adding of SO_2 is controlled by a treshold gauge amplifier operated by the analyzer.
Three ventilators circulate air to avoid gradient formation of SO_2 concentration during the experiments.
The chamber is taken at standard pressure by resetting the air consumption from the analyzer through a charcoal filter and a NaOH liquid trap.

b) Sample control

Samples of marble plates (size 55 x 45 x 5 mm) have been employed. Besides 300 μ thickness samples were observed at the microscope under polarized light in order to examine the surface structural modifications.
The samples were hold on metallic plates and fixed with teflon washers (see Fig.2).

Inside the holding plates water, cooled by an external refrigerator, circulates at constant temperature (4/8°C).
The holding plates were gilded to avoid corrosion by H_2SO_4.
On the holding plates two isolated boards are fixed. They support heating resistors (see Fig.3) which can evaporate the water condensed on the samples, at predetermined times.
In this way the condensation/evaporation cycle is concluded.
In order to avoid the removal of material from the sample surfaces it is necessary that droplets do not forme. For evaporating the exceding condensed water a resistance gauge circuit switches on the heating resistors.
Each holding plate consists of four stands: three of them support the samples and the last the "condensation sensor".

c) Mixture $^{35}SO_2/N_2$ preparation

$^{35}SO_2$ with an activity 1.2 mC/mM is supplied by the Radiochemical Center of Amersham (U.K.).
The breaks hill containing $^{35}SO_2$ were kept in liquid nitrogen, until solidification is reached, then it was put inside a gas cylinder. The cylinder was slowly filled with the SO_2/N_2 mixture, 2,000 ppm.
The radioactive mixture has been tested in order to verify its homogeneity by bubbling the gas in samples of 1M NaOH solution. Their measured activity was 8.10^3 cps/l.

d) Evaporating/condensing cycle and radiochemical measurements.

Several series of four samples were submitted to heating and cooling cycles, during one week. After four hours of cooling (or condensing phase), the heating time (evaporating phase) was 30 minutes.
Few series of samples were previously partially treated both with airborne particulate matter and $FeCl_2$ particles, employed as catalyzers of the SO_2 attack.
After the weekly cycle the radioactivity of marble surfaces was measured firstly by Geiger-Müller counter system and then by a radiochromatoscanner (Berthold).
The radiochemical analysis gives the surface distribution of $Ca^{35}SO_4$ microprecipitates. The counting efficiency was 5%.
The map distribution of sulphate was confirmed by autoradiography made by a Kodak AA emulsion. The exposure time varied from 2 hours to 14 days.
The surface modification was controlled by a microscope. A picture of the samples, taken under the stereomicroscope, before and after the treatment is shown in Fig.4.

RESULTS AND DISCUSSION

The considered physical and chemical parameters for better understanding the mechanism were:

a) Condensation/evaporation time

30 minutes heating and 4 hours cooling cycles have been found to be the best time step.

b) Concentration of SO_2 in the chamber

The experiments have been carried out by using two concentrations: 20 ppm and 3 ppm.
In the 20 ppm concentration experiments the surface modifications were too strong (as shown in Table 1) and the high radioactivity disturbed the surface map of $CaSO_4$ precipitates.

	Integral surface activity (counts)	Linear activity (cps)
Sample exposed to 3 ppm SO_2	650	0.5
Sample exposed to 20 ppm SO_2	275,000	4.10^2

Table 1

The 3 ppm SO_2 concentration is nearer to the Venice air pollution and it gives better and reproducible results.

c) Rate of $^{35}SO_2$ oxidation between cycled and wet samples

The sulphate precipitate is more regular on the cycled samples than on the wet ones, as visible in Fig.5 (autoradiography).
The integrated value of the precipitated radioactivity is almost the double in the cycled samples (Table 2).

	Integral surface activity (counts)
Cycled samples	650
Wet samples	350

Table 2

d) Effect of catalytic efficiency both of airborne particulate matter and $FeCl_2$ in SO_2 oxidation on marble surfaces.

In a series of experiments the surface of marble samples has been treated partially with airborne particles collected by EURATOM and $FeCl_2$ (Junge's catalyst)[2] in order to test their catalytic activity on the SO_2 oxidation.
This kind of effect, where air particulate matter was found to be the most active, is shown in Fig.6.
From the graphic it is also evident that the different effect on the cycled and wet samples, is well in agreement with other experiments.
Fig.7 shows, at high magnification, the $CaSO_4$ crystal formation, in the area covered by $FeCl_2$, in cycled and wet samples.
In our opinion, the difference in the quantity of crystals formed is due to the $FeCl_2$ local concentration, lower in wet samples ($FeCl_2$ dissolves in water).

In conclusion this kind of "stone sickness", that is the SO_2 transformation in stable $CaSO_4$, seems mainly to be caused by the pollution particles as well as the effect of atmospheric conditions: heating and cooling of Venice stone and marble surfaces.

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1) O.VITTORI, Venice 1975, Communication at "Stone Materials Group", ICOM,UNESCO.
2) C.E.JUNGE and T.G.RYAN, (1958) "Study of the SO_2 oxidation in solution and its role in atmospheric chemistry" Q.J.Roy.Met.Soc. 84,46-55.

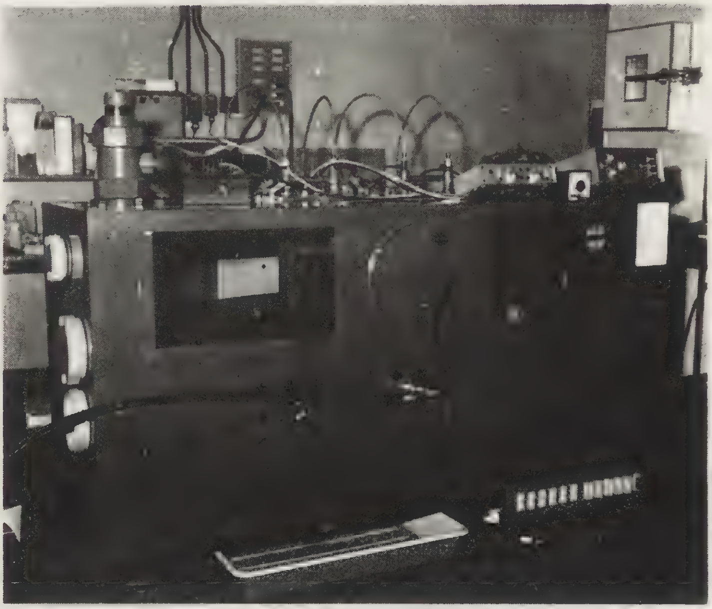


Fig.1 - Climatic chamber

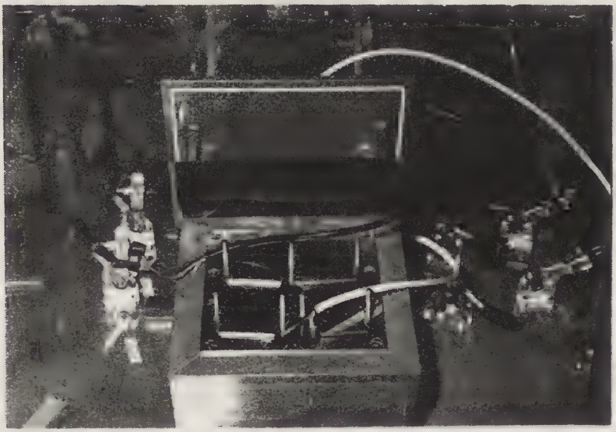


Fig.2 - Sample holder

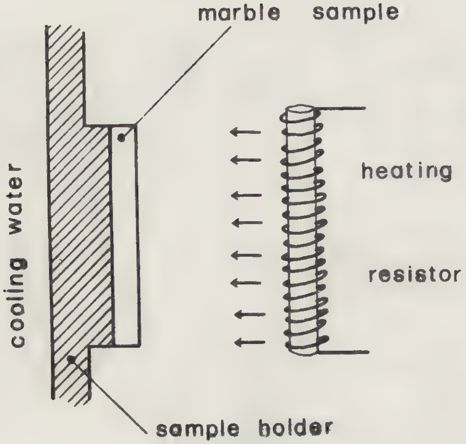
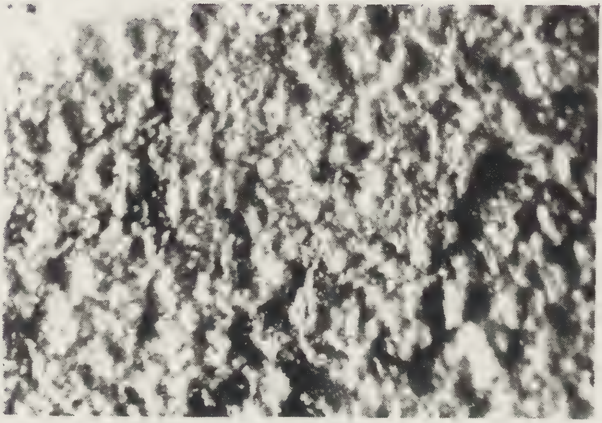
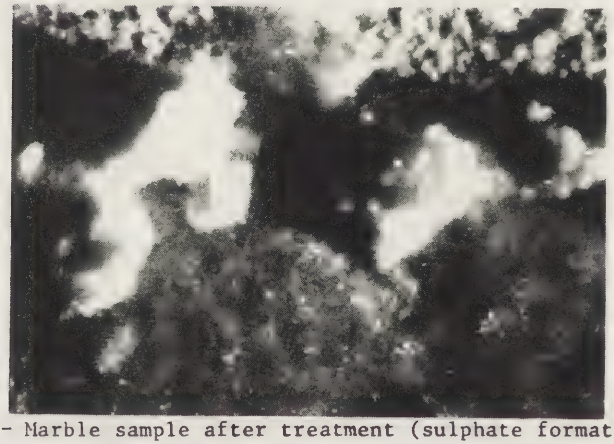


Fig.3 - Condensation/evaporation system

Fig.4 - Magnification 40 x under stereomicroscope

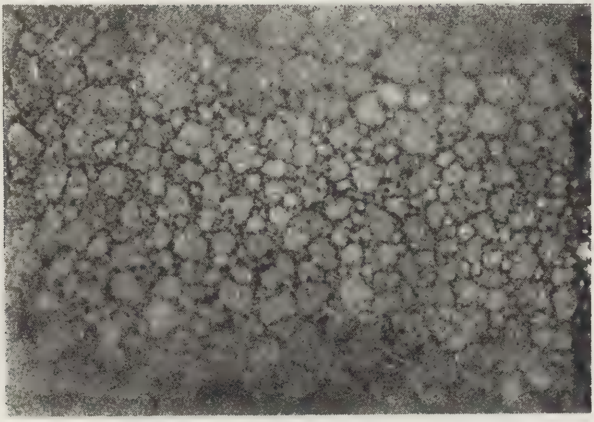


A - Marble sample before treatment

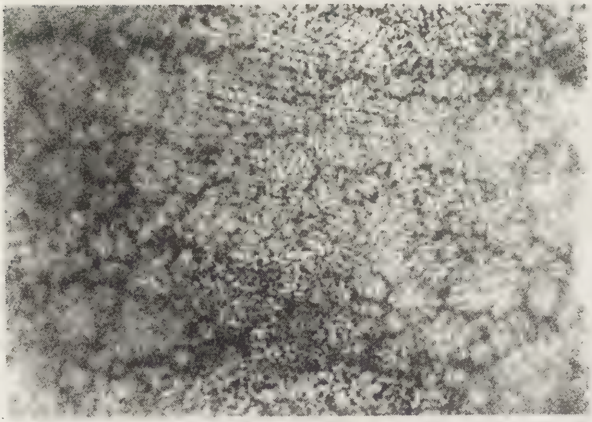


B - Marble sample after treatment (sulphate formation

Fig.5 - Autoradiographies



A - Cycled sample



B - Wet sample

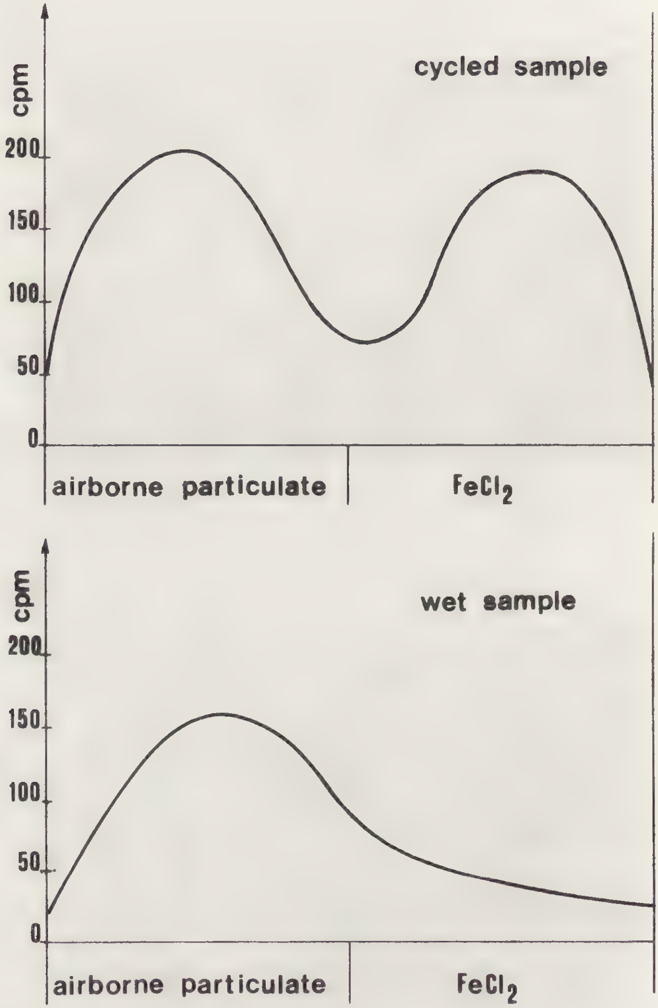
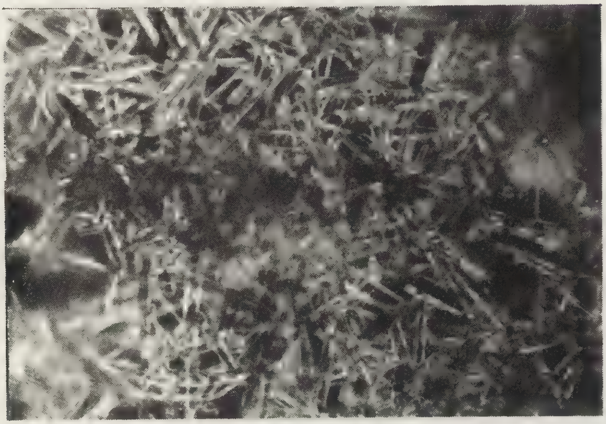


Fig.6 - Radioactivity plot of samples covered by catalysers

Fig.7 - $CaSO_4$ crystal formation in $FeCl_2$ covered area (magnification 500 x)



A - Cycled sample

B - Wet sample

THE SCANNING ELECTRON MICROSCOPE AND MICROPROBE. APPLICATIONS TO CONSERVATION AND HISTORICAL RESEARCH

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Abstract

The historical development, design, operation, and applications of the scanning electron microscope and electron microprobe analyser are described.

Magnification as high as 200,000X and a resolution of less than 10mm are possible with a depth of field 3 orders of magnitude better than the optical microscope. An x-ray analyser permits chemical analysis of the elements to which it is sensitive using the secondary fluorescent x-rays generated in a sample by an electron beam.

Auxilliary equipment needed with this advanced technique, and some likely areas of study for the instrument in conservation and historical research are listed.

I. Definitions

The transmission (or direct, or conventional) electron microscope (TEM) functions in a manner quite analogous to the optical microscope although its physical appearance is different. A beam of energetic electrons (100 KeV or greater) is passed through a very thin sample or replica and detected either photographically or with a fluorescent screen. A resolution of better than 1 nm can be attained (compare a good optical resolution of only 250 nm). The major application of the instrument has been the study of intra cellular details in biological research. The scanning electron microscope (SEM) to be described here, operates by detecting the secondary phenomena which occur when a tightly focused beam of electrons is scanned back and forth over a rectangular area (a "raster") on a sample. The electron microprobe analyzer (EMA) is designed primarily for chemical analysis using the secondary fluorescent X-rays generated in a sample by an electron beam. The instrumentation for the SEM and microprobe is converging in recent instruments. That is, X-ray detectors and analyzers are being added to SEM's and scanning and imaging systems are being added to microprobes; hence they are conveniently discussed together although originally quite distinct.

It should be noted that there are now commercially available analogous microscopes and microprobes which utilize focussed beams of ions such as argon and oxygen. These "ion microprobes" can detect as little as 10^{-19} grams of most elements.

II. Historical

Although electrons were focussed at the turn of the century, the first TEM was not built until 1932. Major design improvements occurred in the period 1935-1950 but are still proceeding, mainly in the direction of reducing lens aberrations and increasing electron accelerating voltage to improve resolution and permit observation of thicker samples. The first commercial TEM was available in 1940.

The first EMA was built in 1951 and commercialization followed quickly. Early instruments had a stationary beam with the sample mechanically positioned using an auxillary optical microscope. Scanning capabilities were soon added but the large beam currents and relatively coarse (500 nm) focussing of the beam did not lend themselves to the best imaging. The requirements of optical positioning of the sample, crystal mono-chromotors for X-ray analysis and highly polished samples tended also to inhibit its use as an imaging device and kept it largely a tool for detailed metallurgical analysis.

The first SEM was built in 1935 but a commercial instrument was not available until 1965 because of the stringent requirements for sensitive detectors and very tight beam focussing (currently a beam size of under 10 nm is available). The SEM's effective marriage with the EMA is largely a development of the last four years since the introduction of solid state lithium-drifted silicon X-ray detectors.

III. Description

A) SEM

The SEM consists basically of a source of electrons at an accelerating potential of 5 - 50 KeV, a column with 2 or 3 magnetic lenses and 2 or more apertures, a scanning coil, the sample positioned on a precise stage capable of being translated, titled and rotated and a detector. All of this is evacuated to 10^{-5} torr. The electronics required to accelerate the beam, control the lenses and scanning coils, operate the detector and display the image are separately housed. In operation, the sample suitably prepared is inserted, the column evacuated, the electron beam turned on and focussed, and the sample positioned for the view desired. The beam is scanned in raster fashion over the sample and various phenomena are induced in or by the sample. Electrons may be reflected (backscattered) or secondary electrons produced. These are detected by a scintillator crystal mounted on a photomultiplier. Some materials will emit visible light (cathodoluminescence) which can be detected by a photomultiplier or photocell. A current will be induced in conductive samples and can be monitored by a sensitive ammeter placed between the sample and ground. X-rays are produced and can be used to display a map of the distribution of a given element in the sample. Auger electrons are produced and appear as a fine structure on the secondary electron emission. When detected and analyzed by an electron spectrometer, very detailed information can be obtained about the composition and oxidation state of elements in a sample. If the sample is sufficiently thin an electron detector can be placed beneath the sample and the instrument operated in a transmission mode (although not with the resolution of a TEM). These various modes can be shown singly or combined to provide an information-rich picture.

Imaging is provided by an oscilloscope which is scanned synchronously with the electron beam raster. The oscilloscope brightness is modulated by the signal from the detector in use, thus providing a picture. Since the size of the oscilloscope is fixed, magnification is controlled by the size of the electron beam raster. For example, if the oscilloscope is 10 cm on a side and the raster on the sample is 10μm, a magnification of 10,000X results; if the raster is 1μm, the magnification will be 100,000X. The oscilloscope can be observed visually or photographed for a permanent record. TV recording is also possible.

Resolution, is of course, determined by the size of the focussed beam, typically 10 nm in a good instrument (although 3 nm is available with a field emission electron source) and by the mode of operation. The best resolution is with secondary electron imaging; X-ray, cathodoluminescence, and current imaging will be an order of magnitude worse due to the spread of the beam within the sample.

Sample preparation is relatively easy but two requirements must be met. Firstly, since the sample must be observed in a vacuum, if it contains volatile materials such as water, these must be removed. If the sample has delicate structural components, techniques such as freeze-drying or critical point drying may be required. Secondly, if the sample is not an electrical conduction, electrical charge-up which distorts and obscures the image must be prevented by providing a suitable coating,for example, a 20 - 50 nm vapour deposited layer of gold or aluminum. A coating of heavy metal also enhances secondary electron emission but, if X-ray analysis is to be performed, it must be chosen so as to not interfere.

The acceptable sample size range is relatively broad: from a single microscopic speck up to an object several centimeters on a side depending on the specific instrument used. Topographical information can be obtained from samples which cannot be put in the chamber, by preparation of replicas.

Tabled below is a comparison of typical values for resolution, magnification range, and depth of field for the TEM, SEM and optical microscope.

	Optical	SEM	TEM
Resolution (nm	200	<10	<1
Magnification (X)	1-2, 000	10-200,000	1,000-1,000,000
Depth of Field 10X	0.1 nm	10 mm	
100X	1 μm	1 mm	thin sample
10,000X		1 μm	

Note especially that, in addition to much better resolution, the SEM has a depth of field 3 orders of magnitude better than the optical microscope. This permits observation of structure and surface relief impossible optically. The bulk of SEM work is done at magnifications of a few hundred X to, say, 25,000X but its depth of field makes it the instrument of choice for many problems.

B) X-ray analysis

Only the briefest description of X-ray fluorescence can be given here. In essence, elements excited by electrons (or other radiation) emit X-rays the energies of which are characteristic of the elements present and which can be used for analysis. Two types of X-ray analyzers are currently in use as adjuncts to SEM's. One or more conventional crystal analyzers can be fitted around an SEM column. These suffer from their relatively low efficiency of detection. This means higher and possibly damaging beam currents must be used, analysis is slow and that usually only one element can be detected at a time. However, light elements (down to boron) can be detected. The solid state silicon or germanium detector (EDX) is an energy dispersive device, detects and displays all of the X-rays, to which it is sensitive, simultaneously and has much higher efficiency permitting rapid analysis, low beam currents and hence better spatial resolution. Its disadvantages are poorer separation of the X-ray energies and a light element limit of sodium (oxygen with special installations). In general the EDX analyzer is the instrument of choice for most work. Special requirements for light element work or overlapping lines may require the crystal or wave-length dispersive analyzer. The crystal monochromator requires that the sample have flat, smooth, carefully positioned surfaceswhereas, in principle the EDX analyzer does not. However in practice, scattering and secondary excitation make X-ray analysis of very rough samples uncertain even with the EDX system. Both qualitative and quantitative analysis is possible, the former being much simpler. The depth below the surface from which elemental information is obtained depends strongly on the density and atomic weight of the sample ranging from a few tenths of a micrometer to several micrometers.

IV. Equipment.

SEM's ranging in cost from \$20,000 to \$90,000 are available from various manufacturers. These include: Advanced Metals Research Corp., Cambridge Scientific Instruments Ltd., Cameca, Coates and Welter Instrument Corp., Etec Corp., Hitachi (Perkin-Elmer Corp.), JEOLCO, Phillips Electronic Instruments, Semco (Carl Zeiss) and others. The higher priced instruments, in general, offer the best resolution, better sample handling facilities, a wider range of options and accessories and improved ease of switching from one mode of operation to another. They are also more complex and require greater operating skill to fully utilize their capabilities. For purely photographic work, obtaining SEM photomicrographs can be as simple and routine as operating a good camera.

X-ray analysis facilities of the crystal or wave-length dispersive type are usually supplied by the manufacturer of the SEM. EDX detectors and analyzers are available from various suppliers at a cost ranging from $15,000 to $35,000 depending on sophistication and degree of automation. They must be purchased with the specification that they be interfaced by the manufacturer to the specific SEM in use. Suppliers include: Canberra, Edax, Kevex, Northern Scientific, Nuclear Semi-conductors, Ortec, Princeton Gamma-Tech.

Auxillary equipment needed will include a vacuum evaporator for sample coating, drying equipment, sample handling tools, a stereo-viewer since stereoscopic imaging is possible and useful with an SEM and will cost approximately $5,000 minimum. Any installation of an SEM should be done seriously with provision of a full time operator, a separate (small) laboratory, an adequate budget for supplies and maintenance. If microprobe analysis is to be done, the operator will require a good background in physical chemistry.

V. Applications

As with any advanced technique applications are determined largely by the ingenuity of the user. This is and will remain an optimal instrument for the study and analysis of the small, heterogeneous samples encountered in museum work. Applications in this field have, to date, been limited by the relative scarcity and high cost of SEM or microprobe installations. Notable exceptions to this have included Young and Ogilvie in Boston, Smith and Lechtman at MIT, the British Museum work on paper and the recent work of Taylor and Myers in Ottawa. Art and Archaeology Technical Abstracts to 1973 lists 21 entries for SEM work and 29 for EMA. Not all of these, of course, are museum applications but the field is growing rapidly and has its own extensive literature. Some obvious areas of study applicable to conservation and historical research are:

1) Analysis of multiple paint layers in cross-section.
2) Identification of pigment origin on the basis of details of particle size and shape.
3) Study of the structure, deterioration and fibre type in textiles and paper. The SEM is particularly useful here because its depth of field permits observations which are otherwise impossible.
4) Identification of impurities and residues in fibrous materials as above.
5) Study of the structure and debris in waterlogged wood.
6) Analysis of corrosion products and processes in metals.
7) The study of the penetration and concentration gradients of one material into another.
8) Identification of grain structure, inclusions, and alterations in stone, ceramic and metal objects.
9) Study of fracture surfaces, wear marks, and partially defaced or worn surface decorations or proof marks by preparing surface replicas which can be placed in the SEM. Here the basckscattered electron mode is useful since it is particularly sensitive to topographical detail.
10) Identification of biological fragments.

75/4/4-1

RESEARCH PROJECT ON PIGMENT IDENTIFICATION AND CONTROLLED NATURAL ALTERATION THROUGH AGE

Interim Report

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Abstract

An investigation is in process to develop a key system using different methods of photoregistration of painted surfaces, of known composition, by which at least a number of pigments could be identified directly on the whole surface without taking samples. The acquired information of the recording is valid for the whole surface of the art object under investigation. The basis of the research is the recording of reflected or excited irradiation in the visible, UV and IR spectrum through special filters and lenses on different photographic material.

Objectives

It is intended to find photo-optical methods to identify pigments in paint without taking samples. The result of the investigation should give information about a whole surface recorded in this way, as the scientific techniques used to date only give information about the sample analysed or the spot irradiated.

Once established, a key-system should allow any well equipped and trained conservator to carry out the investigation on his own.

The progress of the research will show, to what extent information about dyes and lacquers, binders and coatings can be obtained, using the same recording system.

Approach

To obtain controlled research-conditions 95 pigments in 5 different binders were painted on individual small lime-wood board, in a precisely recorded manner all analogous to the known classical techniques of painting.

The manner of fabrication of the pigments and materials used on the sample-boards, the supplier, the grade of purity, the chemical constitution are recorded and controlled.

All ninety-five pigments used in this project have been analysed by X-Ray Diffraction by John Taylor, Senior Research Chemist with the Canadian Conservation Institute, Ottawa. Apart from one, all pigments showed an extremely high purity and are now used as standards in the Canadian Conservation Institute. The chosen system shows one pigment on a surface of 90 square cm in 90 different situations: on three preparations, in five binders, under four different varnishes in two different light exposures.

State of project

All limeboards are painted and recorded. They are awaiting varnishing. All materials used are identified and recorded. By the end of the year the actual research into identification-possibilities will start. UV Reflectography and fluorescence, IR-reflectography and possibly - fluorescence, monochromatic filters together with quartz-lenses on different photographic materials will be used, as well as Infrared false colour film.

Application and limitations

By the nature of the project the method will allow identification of areas of paint made of one pigment only eg. cinnaber. Mixtures will not respond. Thus polychromies of sculptures, illuminated manuscripts watercolours, paintings of so called 'primitive' periods and modern art of the 20th century, as well as painted ethnographic material are best suited to analysis in this manner.
Colour schemes like those used in the dutch 17th century art or the italian baroque will hardly be investigated this way.

Acknowledgements

Co-author of this project is Alexander Voute, dipl. phys. ETH at the Swiss National Museum in Zuerich. I should like to thank Dr. B. Muehlethaler; Ass. Prof. Jim Hanlan, John Taylor B.Sc. M.Sc. for helpful discussion and assistance, as well as J.C. McCawley, B.Sc., M.Sc. F.S.A.SCOTT.

DIAMOND CELL INFRARED SPECTROSCOPY IN THE ANALYSIS OF PAINTS AND PIGMENTS

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Abstract:- Diamond cell infrared spectroscopy and its application to paint and pigment analysis is described. The progress to date shows a technique allowing easy, rapid, routine analysis of samples as small as 4 micrograms. Preliminary sample preparation is almost unnecessary and the sample can be easily recovered almost quantitatively for further study. The technique is especially suitable for solid samples (1,2) and can provide information of pigment and media on the same small sample.

Introduction

Infrared spectroscopy is generally considered to be the best single technique for the analysis of paint samples. The emphasis has always been, however,on the organic constituents such as media, resins, varnishes (3,4), and rarely on the identification of pigments. This has mainly been due to the problems associated with the handling of solid samples (5). Often the modifications made to other micro-techniques have had disadvantages, either in sample handling, sample preparation, or the range and quality of the spectrum obtained (6). In addition to the difficulties of handling solids one is constantly faced, in the analysis of painting materials, with the general problem of obtaining different kinds of information from very small samples.

It is desirable then to use a technique which does not consume the sample; which only requires a very small sample; gives information about pigment and media; requires no sample penetration or sample splitting. This paper will outline the technique of diamond cell infrared spectroscopy and illustrate the results of our preliminary work on its application to paint samples and pigments.

Diamond Cell Infrared Spectroscopy

The technique utilizes a cell, which was first designed for optical studies at high pressures (7,8,9). The cell is fitted with diamond windows, to obtain spectra in the 2 to 50 micron region. Generally, high quality spectra with sharp well-defined bands are obtained from samples as small as 4 micrograms using the diamond cell. Preparation of the sample is usually unnecessary and minimises greatly the chance of loss and contamination. Spectra can be obtained in a rapid (approximately 20 minutes), easy, and routine fashion without much of the time-consuming procedure of other techniques. Especially attractive is the fact that the sample is not consumed and can be easily recovered for analysis by x-ray diffraction, emission spectroscopy etc. In some applications this is done without removal of the sample from the cell (10). The sample during the loading is easily viewed through a microscope which facilitates the detection and removal of impurities. Because no sample preparation is necessary and the technique is simple there are virtually no instrumental variables to monitor and reproducable results are much easier to obtain. This is of course essential when using reference spectra and for interlaboratory projects.

Description of Diamond Cell

Figure 1 shows a schematic diagram of the high pressure diamond cell. It consists of three basic parts: the optical cell, its holder, and a mechanism for applying pressure. Two, type II, diamonds (A) polished to form parallel faces form the optical cell. Each diamond having a working surface about 0.7 mm in diameter, is set into a steel piston (B) fitted with alignment mechanisms to prevent twisting. The pistons slide into a hardened steel cylinder (C) that itself fits tightly into a cylindrical hole in the steel block which carries the pressure generating mechanism. The lower piston rests against a narrow flange in the steel cylinder whilst the other is pressed down by a pressure plate (D). A pivoted lever (E) connects the pressure plate to a calibrated spring (F). The pressure is applied by a manually operated screw (G). To allow a large cone of radiation to be transmitted through the diamonds the steel pistons and the pressure plate have conical holes drilled in them. The sample is located between the diamond windows at the focus of this cone of radiation. The faces of the diamonds are ground to have different surface areas to avoid axial alignment problems.

Because of the transmission properties of natural diamonds only type II are used since they are transparent in the essential 'fingerprint' region of the spectrum. Spectra 1 shows the infrared spectrum of a typical type II diamond. One of the disadvantages of the diamond cell is that the region from approximately 2400 to 1800 cm^{-1} is obscured by a very strong absorption. The region between approximately 3500 to 3000 cm^{-1} has bands of medium intensity but can still be used. Weak bands in this region however tend to be masked.

Infrared Equipment

A Perkin Elmer, model 567, double beam, grating spectrophotometer is used because its extended range (2.5 to 50 microns) is especially useful in pigment identification. The sample is placed in the diamond cell which is fitted into the focus of a Perkin Elmer, 4X reflecting beam condenser (see Plate 1). Because only a small amount of the available energy from the source is utilized a mechanical attenuator is used to restrict the reference beam and allow the full scale of the instrument to be used.
Instrument settings: these are normally slit 7, scan speed medium or slow, time constant 1.

Sample Handling

Sample handling is simple and in most cases requires no preliminary work such as grinding, mixing, etc. Solids: The piston with small diamond is placed on the stage of a low power stereo microscope. A small sample of the powder is placed on the surface of the diamond with a needle or small spatula (see Plate 2). The second piston is placed on top and hand pressure applied to form a thin film. Too large a sample is not a problem as the excess is extruded from between the faces. The two anvils are then slid into the bearing and the pressure plate placed over and screwed lightly into place. Only a minimal amount of pressure is needed in Infrared work. If the microscope stage is transparent light can be transmitted through the cell and show if the sample is correctly placed, and of the right quantity. With experience samples of 10 micrograms or less can be handled with comparative ease. Because of the small size requirement individual layers of a paint chip can be sampled using a fine needle.

After analysis the sample is easily removed from the diamond and can be used for further investigation.

Liquids: Using a small hypodermic syringe liquid samples are easily applied to the diamond face. Alternatively, a gasket of aluminum or teflon with a hole smaller than the area of the diamond window can be placed on the diamond and liquids placed into the space. Oils or grease are best smeared on using a pin.

Spectra

The exploratory nature of this work must be emphasized. No attempt has been made to make any assignment to individual bands. It is intended only as a means of visual comparison to show the quality, and the differences of spectra obtained with the diamond cell. Infrared spectra are interpreted by reference to standard collections of spectra (11,12) and by comparison with spectra of known pigments. In many ways the use of infrared for pigment identification is only as good as the number of reference spectra available.

Spectrum 1 shows the absorption from the empty diamond cell. It can be seen that the whole of the important 'fingerprint' region is free from absorptions.

Spectra 2,3,4 are of Mexican azurite, azurite with oil, and linseed oil, respectively. Comparison of 2 and 3 show how clearly the absorption due to the oil (marked with arrows) can be seen on the azurite spectrum. The size of sample in all cases was between 4 and 5 micrograms. Spectrum 5 of prussian blue has strong bands at 1412, 605, 495, and can be easily recognized.

Spectrum 6 is of artificial ultramarine and it can be seen that this and the other blue pigments shown have spectra quite different. Vermillion, spectrum 7, is normally considered inactive in the infrared, mainly because the region between 16 and 50 microns is not available with most instruments. However, the sharp band at 340 and the poorly resolved doublet at 280 cm^{-1} are easily recognized. The green pigments, Scheeles green, Spectrum 8; Veronese green earth, Spectrum 9; and green natural umber, Spectrum 10, clearly have quite different infrared spectra.
Spectrum 11 of raw sienna ($Fe_2O_3.H_2O$ and α-quartz) is noticeably different from those of burnt sienna (Fe_2O_3, $CaCO_3$ and α quartz) spectrum 12, and burnt umber (Fe_2O_3,$CaCO_3$, and α quartz) spectrum 13, which are chemically very similar. The latter two spectra do however contain slight differences which further work may be able to characterise. In all these spectra the three characteristic bands of iron oxide can be seen: these are 560, 480 and 340 cm^{-1}. The 560 being somewhat broad and the 480 slightly more intense than the other two. However, at the present stage of the investigation it is difficult to distinguish between the pigments based on iron oxide.

Other common pigments examined but whose spectra are not shown have characteristic absorptions in the infrared. For example:
Titanium dioxide: very broad, intense absorption between 700 and 300 cm-1. The envelope separates into two poorly resolved bands at 340 and 350 cm^{-1}. Lead chromate: a moderately broad band at 850 cm^{-1}.

Barium sulphate: a broad, intense band at 1100 and a small singlet at 980 cm^{-1}. At 630 and 610 a doublet with 610 slightly bigger than 630. Calcium carbonate: a very broad band at 1400 and a sharp band at 870 cm^{-1}.

Summary

The results of this preliminary study of diamond cell infrared spectroscopy show that it is possible to make identification of pigments and media on paint samples as small as 4 micrograms. Virtually no sample preparation is necessary and the sample can be recovered for further investigation.

It seems probable from the limited amount of work that has been possible to date that the technique will be useful in distinguishing between very similar types of pigments and for the analysis of lakes, dyes and fibres. Work is continuing in these areas at the present time and the results will be presented at a later date.

Acknowledgments

I should like to thank my colleagues Mr. M.E. Salmon, for helpful discussion, and Mr. H.C. von Imhoff, who made available the pigment and paint samples.

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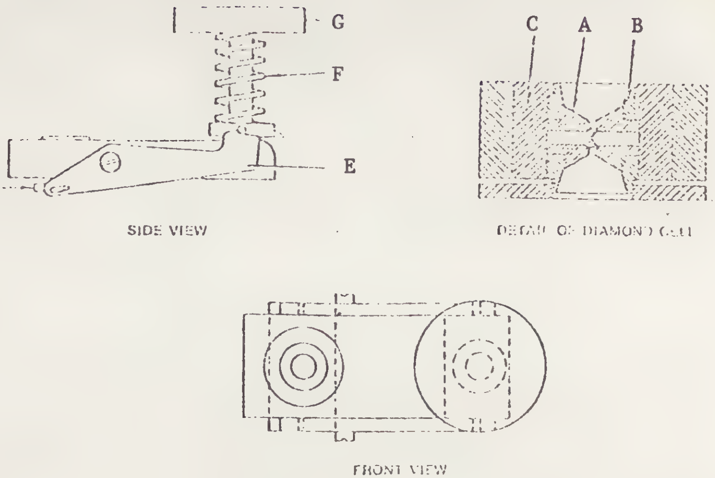
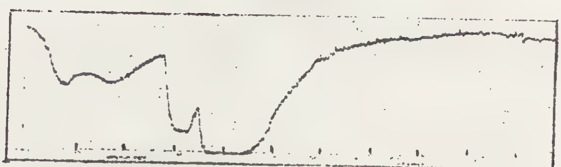
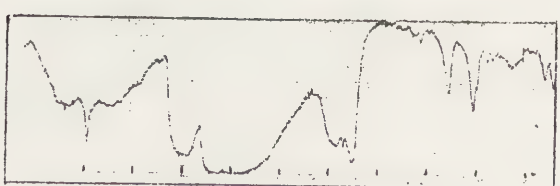


fig. 1

SPECTRA

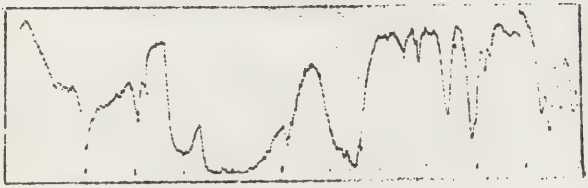


1. Empty Diamond Cell

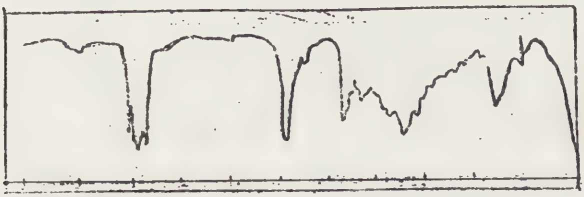


2. Mexican Azurite

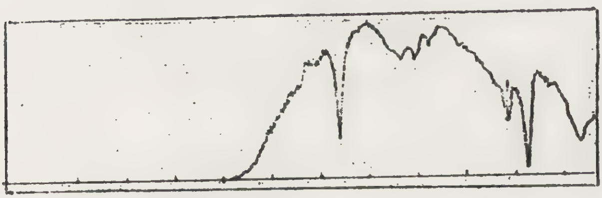
10. Green Natural Umber



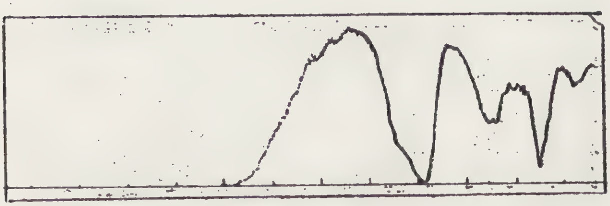
3. Azurite/Oil



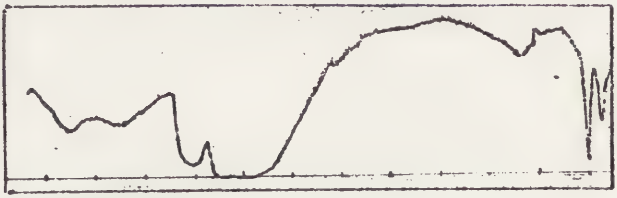
4. Linseed Oil



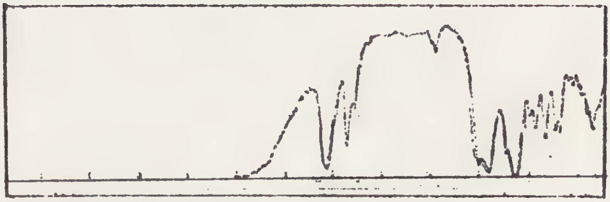
5. Prussian Blue



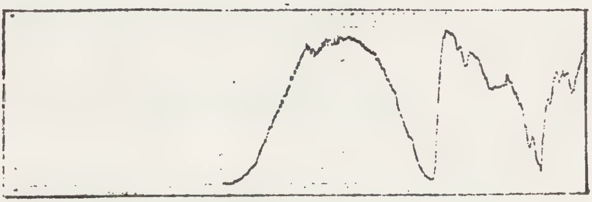
6. Artificial Ultramarine



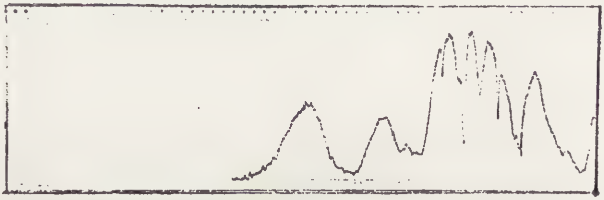
7. Vermillion



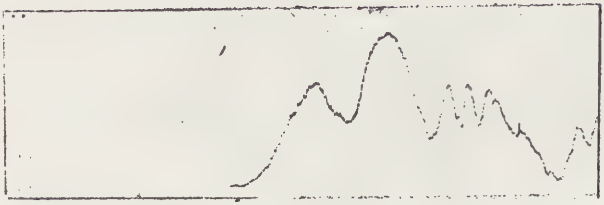
8. Scheeles Green



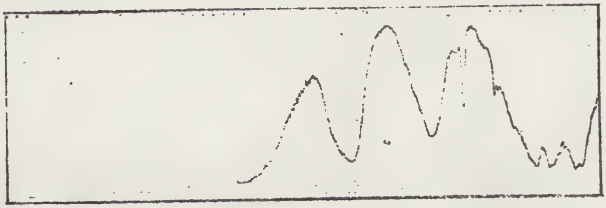
9. Veronese Green Earth



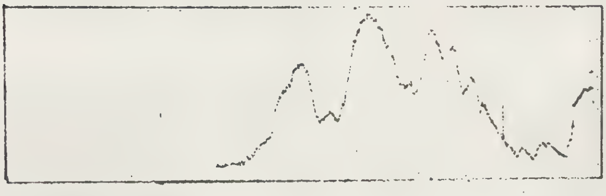
10. Green Natural Umber



11. Raw Sienna



12. Burnt Sienna



13. Burnt Umber

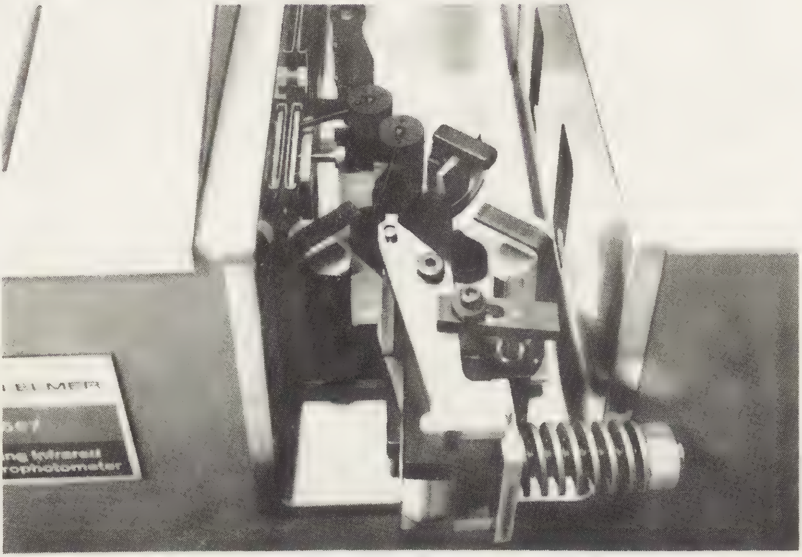


plate 1

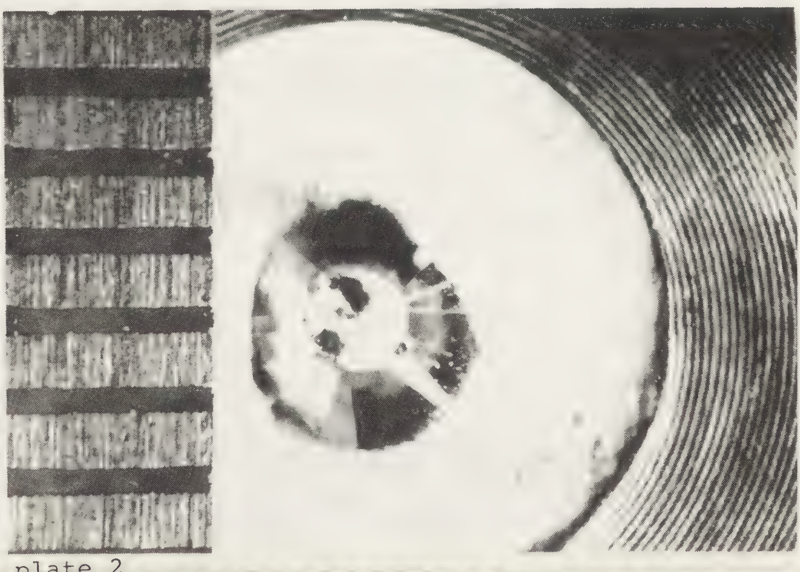


plate 2

LA MICRO-FLUORESCENCE X APPLIQUÉE À L'ÉTUDE DES PEINTURES ET DES OBJETS ARCHÉOLOGIQUES

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L'analyse des peintures et des objets archéologiques doit, par souci de conservation, être effectuée à l'aide de méthodes physiques non destructives. Les rayons X répondent à cette nécéssité de ne pas porter atteinte à l'intégrité des objets, ils permettent de déterminer la composition chimique élémentaire, d'identifier les corps cristallisés et de prolonger l'examen jusqu'à la structure de la matière.

L'une des méthodes utilisées au Laboratoire de Recherche des Musées de France, la micro-fluorescence X, répond aux impératifs de conservation que doit respecter tout laboratoire de Musée. Elle est en effet parfaitement non destructive, permet de connaître la composition élémentaire des différentes parties des objets archéologiques ou des peintures.

PRINCIPE DE L'APPAREIL

On sait que la spectrométrie de fluorescence X consiste à identifier les différents rayonnements X secondaires qu'émet un échantillon excité par un rayonnement primaire de plus courtes longueurs d'onde. La lecture du spectre donne l'analyse élémentaire de l'échantillon.

Cependant les spectromètres classiques de fluorescence X ne sont pas adaptés pour effectuer l'analyse directe d'objets volumineux ou de très petits échantillons.

Etant donné la diversité des problêmes qui nous sont posés, il nous a paru souhaitable de mettre au point un appareil de micro-fluorescence X de manière à permettre l'analyse des objets ou des tableaux sans avoir à effectuer de prélèvements, ou pouvant opérer sur des micro-échantillons.

DESCRIPTION DE L'APPAREILLAGE

L'installation se compose de deux parties indépendantes :

- un chevalet porte tableau et porte objet qui peut se déplacer verticalement et latéralement sur des rails fixes;

- un chariot qui supporte le goniomètre et peut se déplacer parallèlement et perpendiculairement par rapport au plan du tableau.

Le goniomètre est incliné à 45° et fixé sur un socle monté sur le chariot. L'inclinaison à 45° est nécéssaire pour la mise en place des objets. C'est en effet le cas le plus favorable puisque le tableau est alors en position verticale.

Dans notre équipement, l'excitation de l'échantillon est effectuée par un tube à rayons X.

Des contrôles de sécurité ont montré l'utilité d'une protection en plomb supprimant le rayonnement diffusé par l'échantillon.

Notre équipement comporte deux adaptations : la première est composée d'un système à dispersion angulaire (cristal analyseur et détecteur mobile) tandis que la seconde comporte un analyseur multicanal fixe.

AVANTAGES ET LIMITES DE LA MICRO-FLUORESCENCE X

La microfluorescence X est intéressante car elle permet d'opérer directement sur un objet ou sur une peinture. D'autre part, et cela est essentiel, elle est totalement non destructive. L'échantillon peut être récupéré après l'analyse et son étude poursuivie par d'autres procédés. Enfin, la microfluorescence X ne nécéssite aucune préparation de l'échantillon. Elle est extrêmement fiable et très sensible. Son fonctionnement est relativement simple.

Mais comme toute technique, la M.F.X. présente des limites qui tiennent principalement à la largeur de la surface explorée par les collimateurs qui est très faible puisqu'elle varie entre 6 et 0,005 millimètres. De plus, jusqu'à présent, l'appareil ne peut analyser que les éléments dont les numéros atomiques sont supérieurs à celui de l'aluminium.

La résolution angulaire est une caractéristique très importante du spectromètre. Certains éléments présentent des raies très rapprochées qu'une bonne résolution angulaire de l'appareillage permet de séparer, et par là d'identifier.

Le pouvoir de résolution angulaire obtenu avec la M.F.X. est bien meilleur que celui obtenu avec les spectromètres de fluorescence classique.

Pour déterminer l'ordre de grandeur de la plus petite partie décelable par l'appareillage, nous avons opéré sur ce que nous avions de plus petit et de bien calibré au Laboratoire : un fil de tungstène de 6 microns de diamètre. Le collimateur de 10 microns a exploré un volume sensiblement égal à celui d'un cylindre de 10 microns de haut et de 6 microns de diamètre, ce qui correspond à un poids de 5,6 nano grammes. Cette quantité de matière est détectée avec un rapport pic/bruit de fond voisin de 10. La limite de détection se situe autour du demi-nanogramme.

LES APPLICATIONS DE LA MICROFLUORESCENCE X

a) l'analyse des peintures

La microfluorescence X permet d'identifier les pigments constituant les couches picturales à partir des résultats de l'analyse élémentaire.

Les prélèvements effectués sur les tableaux en vue de l'analyse de la matière picturale doivent être par souci de conservation aussi peu nombreux que possible. C'est pourquoi la microfluorescence X en fournissant une analyse directe non destructive des pigments par exploration de la surface du tableau, est une méthode particulièrement intéressante pour la connaissance de la matière picturale de l'ensemble d'une oeuvre.

b) l'analyse des objets métalliques

La microfluorescence X permet d'analyser les objets métalliques de formes variées même très petits, en particulier, les métaux précieux et de connaître rapidement les éléments majeurs et mineurs, sans avoir à effectuer de prélèvements et sans dommage pour l'objet.

Les analyses des alliages or-argent-cuivre sont faites par la méthode des rapports afin d'échapper aux difficultés de mise en place de l'objet. Les résultats sont très reproductibles et la précision expérimentale est inférieure au demi pour cent pour le dosage de l'or et voisine de quelques pour cent pour le dosage de l'argent et du cuivre.

La M.F.X. est également intéressante pour l'étude des bronzes, car elle permet de révéler les différences de composition entre les surfaces corrodées ou altérées et le métal sain.

Les soudures peuvent aussi être analysées in situ, étant donnée la possibilité qu'a l'appareil d'explorer de très petites surfaces. Nous avons dernièrement analysé quantitativement des soudures sur des objets d'or.

c) l'analyse des verres, émaux et mosaïques

L'analyse élémentaire permet de caractériser la nature des colorants des émaux, des mosaïques et des verres. Nous pouvons également donner des précisions sur les techniques de fabrication du verre ou de l'émail.

d) l'analyse des céramiques, des gemmes et pierres dures

L'analyse élémentaire panoramique est obtenue en quelques minutes en opérant directement sur la céramique. Il est donc facile de trier et de regrouper par exemple des tessons ou des objets d'origines différentes.

De même pour les gemmes, l'identification du minéral peut souvent être effectuée par la mise en évidence de certains éléments caractéristiques.

e) l'analyse des préparations microscopiques

L'analyse des préparations microscopiques, telles les coupes de peinture, les coupes métallographiques ou

les lames minces, peut également être effectuée par MFX grâce à l'emploi de collimateur très fins (5,10 et 20 microns).

La MFX permet d'identifier les pigments et la préparation à partir des résultats de l'analyse élémentaire en s'aidant toutefois de la couleur et de la forme des pigments présents dans les différentes couches.

Elle a avantageusement remplacé l'analyse microchimique souvent longue et difficile lorsqu'il s'agit de mettre en évidence des éléments tels que l'étain, l'antimoine, le chrome, le mercure, l'arsenic, le titane, le zinc ou le barium. Sa grande sensibilité permet dans certains cas de caractériser des éléments mineurs présents en impuretés dans les pigments.

Dans les coupes de peinture par exemple, on pourra bientôt localiser dans chaque couche les pigments décelés lors de l'analyse globale de la coupe.

De même, dans les coupes métallographiques et les lames minces de céramique ou de pierre, il est possible d'analyser les inclusions et les minéraux difficilement identifiables ou ceux présents en faible teneur.

Comme dans les autres cas déjà cités, cette méthode d'étude des préparations offre l'avantage de n'être pas destructive et de ne modifier ni la surface, ni la composition de l'échantillon

Nous espérons avoir démontré la diversité et l'efficacité de la microfluorescence X, technique d'analyse complètement non destructive adaptée à l'étude des objets de Musée, qu'ils soient composés ou non d'un matériau conducteur.

Nous retiendrons la possibilité d'opérer sur de petits prélèvements (inclusions de peinture ou de métaux, lames minces) ou de travailler directement sur la surface de l'objet. Les surfaces explorées sont comprises entre 30 millimètres carrés et 20 microns carrés.

La résolution angulaire de la M.F.X. est meilleure que celle des spectromètres classiques de fluorescence X.

La limite de détection de l'appareillage est voisine du demi nanogramme.

Sa mise en oeuvre est simple et permet un examen rapide des échantillons.

Ch. LAHANIER

A NOTE ON THE EXAMINATION WITH INFRARED REFLECTOGRAPHY OF SOME PAINTINGS OF THE GROUP VAN DER WEYDEN/FLÉMALLE

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Abstract

A limited number of paintings of the group Van der Weyden/Flémalle was examined with infrared reflectography to investigate the underdrawings. The results provide additional information, but data on the key paintings are still lacking. The available evidence does not yet allow a more definite disentanglement, but may provide a better insight into workshop practice.

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1. Introduction

The enigmatic Roger van der Weyden/Master of Flémalle problem has given rise to an extensive art-historical literature (1).
The investigation of underdrawings as they can be revealed by infrared photography and - usually more completely - by infrared reflectography could be helpful as an approach to clarifying the attributions. A number of authors have used infrared photographs. Taubert (2) in describing the Louvain Trinity with Four Angels, Van Schoute (3) in a discussion of the two panels in the Capilla Real, Granada. Frinta (4) used infrared photographs for the first time of the Mérode altarpiece. Van Asperen de Boer (5) examined some paintings of this group located in the Netherlands and Belgium with infrared reflectography, but the data did not allow further evaluation of the attributions.
Sonkes (6), using only infrared photographs, discussed the partially revealed underdrawings of a great number of paintings in the group. In evaluating the visible evidence she could draw rough boundaries between various

sub-groups. Veronee-Verhaegen (7) analysed the underdrawings revealed in infrared photographs of the Beaune altarpiece and drew conclusions as to the possibility of three different hands in the underdrawing, with the potential help of an assistant for modeling Roger's underdrawing.

In an attempt to pursue a more extensive collection of data on underdrawings in the group, the authors have examined so far a number of paintings with infrared reflectography which had not been investigated earlier with this technique.

In Louvain, Belgium, the Trinity in the Museum Van der Kelen-Mertens could be examined. A copy of the Prado Descent from the Cross in S. Peter's Church in that city could also be examined. By courtesy of the National Gallery, London, the most important paintings of the group preserved there could be investigated with the reflectography equipment of the Scientific Department.

The limited evidence thus gathered is certainly inade for attempting to disentangle the attribution problems further, but it is hoped that it may stimulate investigations of the key pictures in the group in the not too distant future.

2. <u>The Louvain Trinity</u>

Comparison with infrared photographs (8) shows that the reflectograms reveal the underdrawing more completely, allowing for an easier 'reading'. (Fig. 1)

The drawn composition rarely corresponds with the forms in the paint surface. There is a general lowering of painted forms, e.g. hands, feet, etc., with regard to the underdrawing. Most faces were shifted. Shadows of folds are indicated by hatchings made with fairly short, sometimes slightly overlapping, brush-strokes. These hatchings as visible in reflectograms model the folds rather extensively, while Taubert (2), judging from infrared photographs, encountered this type of hatching only in the left arm of God. (Fig. 2)

Small hooks at the ends of lines indicating folds point to the direction of the shadow in the hollow of the fold and thus prepare the subsequent painting. The more contracted drawn forms of Christ's feet and the left hand of God are clearly revealed. The observations made by Taubert are generally confirmed, but we make a reservation with regard to the author's conclusions, i.e. that the Louvain panel is a copy.

The reflectograms of the entire painting have been stored on videotape (9).

3. <u>The Magdalen Reading</u> (National Gallery, London, Cat. 654)

Reflectograms offer additional information compared with infrared photographs (10) about the underdrawing in the green robe and the cupboard behind the Magdalen.
Fairly thickish lines indicate the folds; their outlines have sometimes slightly been displaced in painting. There is little hatching, but whatever is visible seems to run parallel to the direction of the folds except in some places where a hollow is indicated such as in the left sleeve.
The slight displacements of nose and chin already described by Davies (11) and Sonkes (6) are clearly revealed in the reflectograms; the right eye was drawn in a lower position.
The architecture at the left of S. Joseph was drawn differently.

4. <u>Pietà</u> (National Gallery, London, Cat. 6265) (Fig. 3)

Christ and Mary are quite differently underdrawn from the surrounding figures. While the two Saints' faces are superficially drawn in an almost identical manner as 'type' Saints and the Donor's face is only indicated in a rudimentary way, the faces of Christ and Mary are carefully underdrawn. The position of the eyes was lower in both faces. The body of Christ has been carefully modelled with small parallel hatchings far more 'studied' than the ones used in modelling the robe of Mary. The shift in Mary's left hand is fully revealed.
It might well be that this different treatment reflects to a certain extent the fact that Christ and Mary form a composition to be found in an almost identical way in other Lamentations (cf. Sonkes 6, p. 167 ff.), while the Donor and Saints could have been added around this 'standard' composition. The fact that the left arm of S. Jerome was drawn in an upright position protecting the head of the Donor instead of touching that of Christ could be interpreted as confirming the original independence of these two elements in the composition as suggested by Sonkes (6). The black robes of the Donor and S. Dominic cannot be penetrated with infrared reflectography and thus no underdrawing could be revealed in these areas. In a number of places the contours of this robe are visible and in view of the modifications in the Donor's face and hands it may be supposed that in this area the position was tentatively sought as well.

5. <u>The Exhumation of S. Hubert</u> (National Gallery, London, Cat. 783)

The displacement of the faces of the second plan figures already discussed by Davies (11) is confirmed and made more evident by infrared reflectography. Shifts in the faces are perhaps comparable to those in similar figures

of the same size in the Antwerp Seven Sacraments altar-piece reflectographed earlier by the second author (5). The underdrawing of the third plan faces behind the screen would also seem comparable to similar smaller faces in the Antwerp triptych: just a few horizontal brush-strokes indicate eyes, nose and mouth. The eyes of the second plan figures are, in contrast, well articulated in both paintings.

The faces of the group at the right speaking to each other have been turned more towards each other in the painting stage. The priest had a differently cut robe. The bishop at the right had a much slimmer face with a far less pronounced chin-line. This face like others of this size is hatched to indicate shadows.

The inner angels on top of the screen were underdrawn in a more central position; this, together with a modification in the altar, would indicate that the orthogonals converged at a lower point originally.

The robes of the foreground figures were drawn in outlines and fairly carefully hatched.

The different treatment of the underdrawing in various plans has been observed earlier in paintings of the group Engebrechtsz (12). Recently Veronee-Verhaegen (7), commenting upon the underdrawings on the Beaune altarpiece, suggested that different hands could be responsible for underdrawings of dissimilar style in one and the same panel. Perhaps this would occur more in larger panels. The Antwerp Seven Sacraments altarpiece also shows a different style of underdrawings in the angels and the figures in the foreground. It would be most interesting to investigate the paint-layer structure in such large altarpieces to see whether, indeed, a different style in underdrawing would also be reflected in a different painting technique. In such a way the role of assistants in drawing and painting could perhaps be better defined. We do not, however, adhere to this hypothesis a priori.

6. Copy of the Prado Descent from the Cross (Louvain, S. Peter's)

The copy of the Prado Descent from the Cross reflectographed in the sacristy of S. Peter's, Louvain also showed an underdrawing. In the central panel the differences between the underdrawing and the painted stage are slight; the inside lateral panels show many modifications. This would seem normal, as the shutters represent the Donors of the triptych (1443), the Edelheer family, and there is no reason to suppose that they had any connection with the original panel. A close study of the underdrawing in this triptych could be helpful in bringing some order in the numerous copies of Roger's *oeuvre*.

7. Acknowledgements

The authors are greatly indebted to Michael Levey, Director of the National Gallery, London, to J. Crab, Director of the Museum Van der Kelen-Mertens, Louvain, and to the authorities of the S. Peter Church, Louvain and especially to the Chairman of the Church fabric for their kind permission to reflectograph the paintings in their custody. The staff of the Scientific Department of the National Gallery, in particular Garry Thomson and Miss Joyce Plesters, are to be thanked for their help in using the reflectography equipment. The keen personal interest of Alistair Smith, Assistant Keeper of the National Gallery, has been much appreciated.

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Fig. 1. Louvain Trinity. Detail of the head of the angel supporting Christ at the left. (a) Infrared photograph; (b) infrared reflectogram with Heimann 2000 IND infrared vidicon.

Fig. 2. Louvain Trinity. Detail of the robe of the angel supporting Christ at the left. Infrared reflectogram with Heimann 2000 IND infrared vidicon. Hatchings model the volumes of the folds.

Fig. 3. Detail of the London Pietà showing the modification in the arm of S. Jerome. Infrared reflectogram assembly.

STUDY AND RESTORATION OF LOST ANCIENT INSCRIPTIONS ON THE DRY PLASTER BY THE METHOD OF INFRARED AND ULTRAVIOLET PHOTOGRAPHY

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A great number of ancient monuments have preserved on the territory of the Soviet Union. They all are under protection of the Government. Permanent research is carried out in many of them.

In Georgia alone there have been registered about 5000 monuments of architecture. Monumental mural paintings have survived in most of them. Unfortunately, many paintings of the feudal period of Georgia were badly damaged by time. Besides, the repairs and renovations which the monuments underwent in the course of their existence made it impossible for us in most cases to study ancient paintings and to read inscriptions that contain information of a great historical interest. But though the inscriptions faded, crumbled out or were covered with new paintings on the surface or inside the plaster there remain traces invisible for the eye. We suggested an idea to restore such lost inscriptions by means of infrared and ultraviolet photography. After we had mastered this method in the laboratory conditions, we decided

to apply it to study the inscription of the Atheni Temple. The Atheni Temple is situated in the gorge of the Tan River and dates from the 7th century. Here we were to restore and read the extinct inscription in the west apsis. The inscription was first discovered and read in 1956-1957 when part of the frescoes of the temple were cleaned and fortified. As it was understood then the inscription mentioned the name of the Benefactor of the temple and the year 1080 when the frescoes were painted. In scientific literature, however, this interpretation of the inscription was considered doubtful. It was very important to establish an exact date of the frescoes as they are one of the most remarkable specimens of mediaeval monumental art. In 1966 a group of researchers was sent to Atheni to find a final reply to this disputable question. The researchers made it their aim to restore the inscription by exposing it to infrared and ultraviolet rays in the field conditions. Since the inscription was situated at a height of 3.5 metres, a scaffold had to be erected.

The inscription is executed in capital letters in the Old Georgian print "asomtavruli". The original colour of the inscription was light-brown. The first three lines of the inscription are written on the very smooth grey plaster, the other lines are written on the plaster with a rough yellowish-brown surface. The inscription itself is very pale. Only with a great difficulty it is possible to make out approximately one third of the

inscription. The rest of the inscription has preserved in hardly discernible fragments.

As a rule, research involving infrared and ultraviolet radiation must be carried out in the complete dark. That's why the main bulk of research was done after the sunset.

To obtain negatives of a good quality and to find the best method for restoration it was necessary to develop each photo immediately.

Before we got any good result we had to take a lot of pictures using ultraviolet and infrared rays; we also used narrow spectra of these rays. The best result was obtained with reflected short-range ultraviolet rays. To make the scale of photoes larger we photographed the inscription by parts. Eventually we managed to restore the whole inscription and to read it correctly for the first time. Hitherto the inscription was read like this: "Our holy Lady, Virgin Mary, glorify the reign of Giorgi Novolysimos, King of Kings, who was blessed by God and by whose will this sacred temple was painted in khoronikon*T (in the 8th year) of their reign (i.e. in the year 1080 according to our chronology).

After the inscription had been exposed to ultraviolet rays, it was read as follows: "Our Lady, Virgin Mary, grant thy protection and grace to Grigol, the blessed son of Liparit Toreli, by whose will this west wall was painted".

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*The Old Georgian word for "date"

From the point of view of paleography the inscription dates from the 13-14th cc. According to the historical documents Liparit Toreli mentioned in the inscription was a statesman of the 13th c.

The new interpretation of the inscription allows us to conclude that the mural paintings in the west apsis are not original as it was assumed in scientific literature. Since the inscription does not contain khoronikon, we have the right to deny that the frescoes of the Atheni Temple were painted in 1080.

The further investigation showed that the inscription was written above the lost original portrait of Prophet Jeremiah whose name we managed to restore by means of reflected infrared rays. Besides, the photoes showed clearly a different quality of the plaster at the beginning and the end of the inscription.

In 1969 a group of researchers studied the walls of the Atheni Temple by means of short-range ultraviolet rays and discovered a great number of various inscriptions that stood out clearly against the luminescent background. All these inscriptions were photographed by the visible luminescence method.

During the restoration of the temple in 1956-1957 the eight line inscription was discovered in the east apsis of the north wing. The attempts to photograph this inscription by means of infrared rays were not successful because the paint of the fresco that covered the inscription did not trans-

mit infrared rays. Still by means of the solid-state image converter the researchers managed to read the inscription which said: "By will of God in the year RKA Hijra (121) (i.e. in 738-739 according to our chronology) Mampal Stefanoz blessed by God passed away on October 9th on Wednesday at 1 o'clock after midnight of this year".

Below that inscription, on the south wing, there was a short inscription executed in a black paint on the grey plaster. The inscription was completely undecipherable. After it had been exposed to infrared radiation, it was read and it appeared to be a pilgrim inscription.

In one of the niches, under a thick layer of soot, the researchers discovered an ancient cross painted in the early feudal period. They also photographed by means of invisible rays the faded inscriptions that had already been studied and reported in scientific literature some time before. Noteworthy among these inscriptions is the inscription saying that " on the 5th day of the month of August on the Sabbath Day in khoronikon 73 in 239 by the Arab calendar Buga burnt Tiflis and captured emir Sipak and killed him and in the same month on the 26th day of August on the Sabbath Day Zirak captured Kakha and his son Tarhuji".

The researchers collected a lot of scientific materials elucidating new facts in the history of the Atheni Temple.

Very interesting results were obtained by the researchers who studied one of the underground monasteries founded by Georgian statesman David

Garejeli in the 6th century. The monasteries are situated in the village of Udabno at a distance of 60-70 km from Tbilisi. The monastery caves are hewn out in the rocky mountains that divide the basins of the Kura and Iori rivers. The researchers studied the inscription and the two-layer frescoes in the north nave of the main Udabno temple. The second-layer frescoes are believed to date from the 13th century. As to the first layer frescoes there exist various opinions concerning their dating and iconographic scheme. The frescoes in this cave are badly damaged. In the late Middle Ages the walls of the temple were whitewashed and new frescoes were painted above the original ones. As time went by the paint and whitewash fell off and only weak traces of the original and second layer frescoes have come down to us. But these traces overlap one another which makes it almost impossible to understand the compositions and sujets of the original frescoes and to make up their iconographic scheme. It was very important to restore in the best possible way the original paintings.

The ancient Georgian inscription executed in the "asomtavruli" print belongs to the second layer. It is situated at a height of 2.5 metres. The inscription is hardly discernible except 2 or 3 letters. Only the words "this Lukian" can be made out. When the inscription written with white lead was exposed to ultraviolet radiation, it became luminiscent and appeared to be consisting of

three lines. The inscription was in a very poor, almost hopeless,condition because the plaster on which it was written crumbled out and the letters faded almost completely. Still, after the photoes had been developed and studied, the researchers managed to read the words "...this sacristy with altar was painted". Thus the cave turned out to be the sacristy and not the north nave as it was previously assumed.

As to the dating of the original frescoes, the problem here was somewhat more complicated. There was the opinion that the paintings of the main Udabno Temple and its sacristy were painted by the same artist in the 10th century and that they reproduced the scenes from the life of David Garejeli. It was supposed that the scenes were borrowed from the still surviving text of the 10th century which narrates of the life of Saint David Garejeli.

The researchers had to work a great deal before they got any data allowing to repudiate the above-mentioned opinion. As it was the case with the Atheni Temple each photo was developed immediately. The best result was obtained when photographing by means of reflected infrared rays. After the data obtained had been studied, it became clear that the scenes from the life of David Garejeli do not correspond to those described in the text of the first half of the 10th century. As the matter of fact the paintings of the Udabno Temple and the sacristy reflect events of the real life. The frescoes of David Garejeli and his disciple Lukian were painted without nimbi.

The iconographic and stylistic analysis gives the scientists the right to consider that the frescoes in question were painted before the 10th century. This another confirmation of great possibilities of the research method described in this paper.

Very interesting from the scientific point of view was the study of the inscription of the Benefactor's portrait on the Zarzme Temple of the 14th century. The paintings and the temple itself were badly damaged by time. In the 19th century the temple was completely restored. The scientists had a suspicion, however, that during the restoration the inscriptions were changed or distorted. To eliminate the suspicion it was decided to check if the renewed in the 19 century inscription repeated the original one. For this purpose it was necessary to restore the original inscription. The inscription was situated at a height of 4 metres. A great number of photoes was taken by various methods. The best result was obtained with reflected ultraviolet rays. It was found that the inscription rewritten in the 19th century correctly repeated the original inscription except the Benefactor's name which was Sargis and not Sargil.

Research by the method of ultraviolet and infrared photography was also carried out in the cave monasteries of Vardzia,Vanis-Kvabebi, in the cupola-roofed Samtavisi Temple and in other monuments.

When restoring and studying the ancient inscriptions we used all the possibilities of the infrared and ultraviolet photographic method. Success achieved by the researchers of the Georgian State Museum of Fine Arts allows to recommend the method for a broad application for this kind of research as it helps to establish an objective scientific truth with respect to disputable lost or hardly visible ancient inscriptions.

ANAPPROACH OF TOMOGRAPHY

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As a result of using general X-ray method of investigation the total image of all the thickness of an object under investigation. This makes it difficult, and often makes it impossible to investigate separately paint layer of the painting work in the case of an existence of paint layers on both sides of canvas or when back side was painted or stabilized with parketadge etc.

Special ways of investigation such as angled roentgenography are not suitable for our purposes.

Strata X-ray method using in medicine (stratigraphy, tomography) results in too thick and uneven layer image.

In 1949 professor B.Markoni suggested a new procedure to study in pictures by taking plane-rotary radiograms and invented special device for these tasks.

This method is very interesting in many respects but it has some serious defects when put in practice.

X-ray tube for exposure time does only one turn, uniform rotation of X-ray table not provided. Besides that the device mentioned doesn't meet the case of electrical safety and the work with it is accompanied with radiologic hazard of technical personnel.

So take sharp radiograms of paint layers of complicated objects the above mentioned the way and the equipment for CSR (KPR) are worked out.[x)]

The acceptable unsharpness of the image on the film is known to range to 0,2 mm.

That is why the task is set as the following: to take better image detailes of one paint layer (the unsharpness of other image is less than 0,2 mm) and to take unsharp image of snother paint layer on X-ray film, in the other words "to eliminate the image of second paint layer on radiogram while an image of the first paint layer preserred.

X-ray of painting works is taken as the following: The object is placed on the rotatary table so that the paint fragment under study would be on top and be situated between the axis of rotation and the border of the rotary table.

X-rays fall under angle less than 90° and are directed in the centre of the table.

For the exposure time the object is uniformly rotates (see figure)

Owing to small thickness of the paint layer and short distance from this layer and film the unsharpness of an image of the paint layer under study ranges within acceptable limits.

As the elements of the upper paint layer and its image are corresponded to each other for the exposure time (the film stay to lie at that place where it is put at first) the unsharpness depends on the motion of

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x) These way and equipment were worked out and introduced into practice in X-ray laboratory VChNRTs after I.S.Grabar in 1964-1968.

the film in horizontal direction. This unsharpness in linear sizes is greater the less the angle of inclination of X-ray beam. The thinner the layer under study is the better results are obtained.

At the same time there is no correlation between the elements of painting and the image on the film for the lower paint layer when the last one rotates. For exposure time moving paint fragment of the lower paint layer which rotates in horizontal plane relatively the film is projected on the film.

The area of a project of the lower paint layer is much more that its real value (or exceeds in many times the real sizes of a sample). - See table of measurements of control lines of samples. Each paint of the picture when X-rayed is showed as a closed curve.

The more thickness of painting ground is the less angle of inclination of X-ray beam is the more this area is.

For lack of correlation between the painting elements and its images which is due to short exposure time the image of lower paint layer turns into a background which doesn't prevent the experiment. The exposure time in CSR is about 125-130% of the exposure time in the general X-ray method. The possibilities of CSR were completely revealed in the process of studying the work by Alecio Baldunetti (1425-1495) "Madonna with Child" (wood 20 mm thick, oil, sizes - 48,5x38,5 cm). On usual radiogram the image of paint layer is almost covered with the image of the structure of a paint which is covered the back side of a pannel.

On contact stata radiogram an image of the structure of a paint which covered the back side of the pannel appeared to be unsharp. Sharp image of Madonna with

Child has been taken by X-ray way. X-ray shows clamages of paint layer and ground on the background, on the level of her eyes and on her cheek and chin as well.

In this case the damages of an original paint layer and ground were restored and filled with restoration substance of higher density that is why the light fragments of the image on the film are the damages of the work.

The cracks of paint layer and ground coincide the cracks of the pannel. The cracks look like thin, vertical, black bands. The changes in the cloths of Madonna are clearly seen: some pleats in a veil on her head, close to the neck, on her shoulders are painted in other way; the changes in the picture of her sleeves are made.

One may suggest that another paint layer was situated under visible paint layer. The upper (restorative) paint layer is not interpreted on the film.

The closeness of the contact between the film and paint layer influences at sharpness of the image of paint layer in greates degree than the angle of inclination of X-ray beam.

Enough sharp X-ray films of paint layer ajacent to the film are taken even while the image of the lower paint layer on the film is not practically discerned.

Varying the angle of inclination of X-ray beam one could succeed in obtaining the best results (among quiete satisfactory results); under the angles which are less or equal to 50° the results are the most satisfactory. It should be emphasized that under those angles which are less than 50° the darkness of film is made weaker though it is enough to study the layer

ajacent to the film. (See table of measurements of control lines of samples).

We succeeded in dividing two paint layers even in the case when they are at the distance of the thickness of canvas which is covered with ground substance on the both sides.

For example we take the study of icon "Mineja mesjatchnaja". Icon consists of wooden frame 1,2 cm thick; the margines of icon are 3 cm wide, both sides of canvas are covered with levkas on which kovcheg is painted.

The thickness of this fragment of the icon is 0,4cm the icon measures 30 cm x 20 cm.

The images of two paint layers coincide and this makes it impossible to study them.

The dependences were observed as the following:

1. The angle of inclination of X-ray beam and thickness of the works under study are correlated:

a) the thinner the ground of painting work is the less angle of inclination of X-ray beam.

b) the unshaper lower and upper painting layers.

c) the thinner upper paint layer is the less dependence of quality of X-ray radiogram from the angle of inclination of X-ray beam.

2. Sharpness of image on radiogram depends on parametrs of rotation of the subject under study:

a) speed of rotation (in the limits which provide preservation of the subject) is not influenced at sharpness of an image.

b) it is necessary that the subject should make some turns for the time which takes to expose film correctly.

c) the uniniformer rotation is the sharper the image of the upper painting layer is.

3. The influence of degree of contact between film and paint layer at the sharpness of the image of this layer

- the closer contact is the better sharpness of the image.
- according our project rotary table has been worked out and made.

Rotary table is a welded frame with a socket which rotary ring rotates with the aid of bearings. Washer prevents rotary ring from vertical overdrifting. All the rotary part of the table is named as faceplate.

There mounted clamps for objects of various sizes from 30 cm x 30 cm to 200 cm x 200 cm and various thickness from 0,5 cm go 5,5 cm.

Maximum of weight may be no more than 30 kg. Faceplate rotates with the aid of eclectrical engine with remote control. The speed of rotation of faceplate is in the limits from 1 to 10 turns per minute. The number of turns doesn't exceeds in 4-6 per a minute in our studies.

The work of art no dangerous loads for exposure time.

As X-ray generator apparatus RUT-60-20-1 (RUM-7) is used. There is a gradus scale at the holder of a tube.

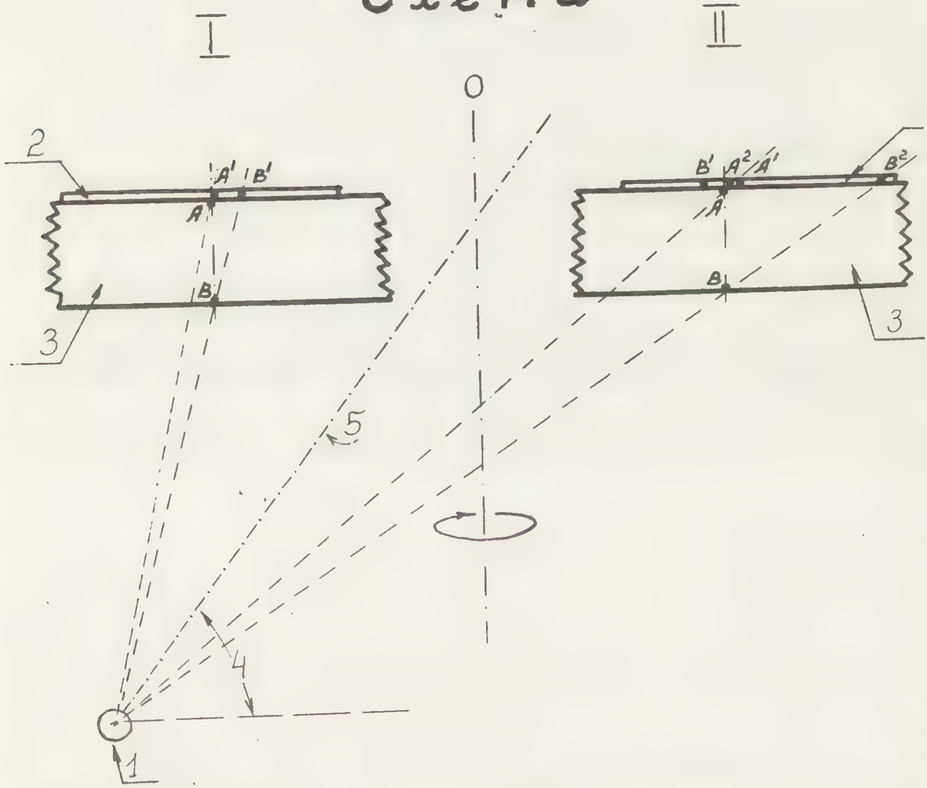
KPR makes it possible to give an idea of structure of paint layer, of existence and the positions of the losses on the paint side under study i.e. permits to study the painting work carefully. This way of roetgenography permits to isolate each of two paint layers if they were at a distance which is equal the thickness of the ground of this work. Isolated layer is thin has one and the same thickness elsewhere. Its

thickness is one and the same

Using KPR method and special equipment worked out on the base of our methods roentgenography laboratory VChNRTs has been taking sharp detailed radiograms of different sides of paint layers which are placed on one and the same ground of painting work, which permit us to obtain neccessary informations about the state of each of them.

We succeded in obtaining good results on isolating two images of paint layers of two-sided picture on canvas, cardboard and thin pannel. Other methods of tomography known us don't give us such possibilities.

Схема



контактной послойной рентгенографии

Scheme

0 - the axis of rotation

1 - X-ray generator

2 - X-ray film

3 - the object under study

4 - the angle of inclination of X-ray tube

5 - the central axis of X-ray beam

Table of measurements of control lines on X-ray film of the samples x)

N° of sampl	Data about samples	Side of sample	90°	80°	70°	60°	50°	40°	30°
			Values of control lines under various angles of inclination of X-ray tube						
1.	Ground-canvas The thickness - 1 mm	face	I	I	I	I	I,I	I,2	I,4
		back	I	I	I,2	I,5	2,0	2,I	5
2.	Ground-pressed cardboard Thickness of it - 4,5 mm	face	I	I	I	I	I,I	I,2	I,4
		back	I	2,I	4	5	7,I	IO,I	I7
3.	Ground-veneer Thickness of it - 11 mm	face	I	I	I	I	I,I	I,2	I,4
		back	I	4,5	9	II,5	I8	24	45
4.	Ground-pannel Thickness -21,5mm	face	I	I	I	I	I,I	I,2	I,4
		back	I	9	I6,5	22,5	34,5	48	86

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x) The speed of rotation in all the cases was 5 turns per minute. The thickness of control lines of the samples was 1 mm. All values of thickness measure in mm.

THE USE OF UV-REFLECTOGRAMS FOR THE EXAMINATION OF PAINTINGS

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A quick routine 'non-destructive' examination of a painting normally comprises photographic recording in reflected, white flat light, oblique light and of fluorescence, an IR-record and an X-ray. Such an examination technique was outlined already in 1916 by the Swedish Nobel Prize winner The Svedberg (1884-1971) and published in an article on the photographic examination of the *Codex Argentus* of the Uppsala University Library (The Svedberg-Ivar Nordlund: 'Fotografisk undersökning av Codex Argentus.' Uppsala universitets årsskrift 1918 Matematik och naturvetenskap I).

Using Polaroid instant films a photographic routine examination of a normal size painting can be carried out in about an hour. (Björn Hallström-Bo Göransson: 'Microbial Environment'. Dokumenta. Stockholm 1972)

In making fluorescence photographs an orange 4 X filter in combination with haze (UV-absorbing) filters may be used to improve the contrasts. If those filters are replaced by a UG (blackish) filter, absorbing the visible light and the fluorescence, the reflected (long wave) UV radiation transmitted by the UG filter will expose normal black and white films producing records which have been called UV-reflectograms in analogy with the terminology used by J.R.J. van Asperen de Boer (Studies in Conservation 14:3, August 1969 p.96 ff. 'Reflectography of paintings using an infra-red vidicon television system.'). The word UV-reflectrogram does not only include photographs but any registration of UV radiation.

The long wave UV-reflectograms thus obtained are easily and quickly made and do not require expensive hardware. A UV-reflectogram may give valuable information about certain types of lining damage (Frantisek Makes-Björn Hallström: 'Remarks on Relining'. Stockholm 1972 pp 35, 40-41) but has also, in some cases, provided information about underlying elements of the painting examined, similar to that of infrared photographs. A third effect which may be observed on UV-reflectograms seems to be connected with certain chemical and physical changes of the varnish. In many cases the UV-reflectograms have a rather confusing appearance and they can hardly be interpreted and evaluated separately. They ought therefore to be collected systematically, brought together and examined comparatively.

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A standard for the photographic routine examination of paintings similar to those of ASTM (American Society for Testing and Materials) could be published within a few years and brought to systematic practical use e.g. by establishing a central information office of the ICOM working group: 'Non-destructive' methods of examination of works of art and their application.

For the presentation of examination results computor and video techniques have proved to be valuable. Such experiments will be presented as a separate project.

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ACID-VAPOUR DERUSTING OF SANDSTONE BUILDING BLOCKS

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Abstract

Sandstone building blocks recovered from the wreck of Batavia were found not only to be lightly concreted but also quite heavily iron stained. The preparation of these blocks for display required the removal of both the concretion and iron stain, the former being accomplished with dilute hydrochloric acid. A series of experiments was carried out to determine the best method for the removal of the iron stain. Of these the use of dilute hydrofluoric acid and hydrochloric acid vapour were the most successful; but from consideration of safety, ease of application and economy the hydrochloric acid vapour technique was concluded to be the most satisfactory method.

Introduction

The recovery of material from the wreck of the Dutch East Indiaman, Batavia sunk in 1629 (1), during the 1972-73 season produced 126 carved building blocks, which together made up the portico of a large building presumably to be erected in 'Batavia' (Djakata). Together the blocks weigh approximately 21 tonnes, the largest ones being $1m^3$ in volume.

Along with the whole blocks a number of broken pieces were also recovered. These had been detached from the main blocks either during the wrecking or subsequently, due to sea action.

All building blocks were covered with a thin crust of concretion, marine calcarous deposit, and some were also iron stained.

Tests on the building blocks showed them to be a typically sedimentary quartzite consisting of quartz grains cemented by a siliceous matrix, which could therefore be acid treated to remove the concretion. Dilute acid treatment of small pieces of the sandstone confirmed this.

The majority of the blocks were cleaned of their concretion covering by immersion in 2% hydrochloric acid (HCl) for one to two days, hosed down to remove excess acid, and then washed in tap water until all acid had been removed.

Motivation

The removal of the concretion layer intensified the appearance of the iron staining and also its uneven distribution on the surface of the blocks. For display purposes it was therefore decided that, if possible, the iron stains should be removed.

Experimental

The iron staining, produced by contact of the blocks with rusting iron objects e.g. anchors, cannon and ships fittings on the wreck site, had penetrated beneath the block surface and could not be removed by simple washing processes. A series of experiments was undertaken to determine the most efficient process for the removal of iron contamination, for which pieces of building block of approximately $1000 cm^3$ in volume were used.

1. As the sandstone was stable in acid solutions for short periods of time, varying strengths of HCl both hot and cold were tried, all the samples being totally immersed in the reagents. The results of these tests are given in Table 1.

Table 1. Effect of hydrochloric acid on the removal of iron stain from sandstone blocks

Acid Strength	Effect		Period of application
	Cold ($18^{o}C$)	Hot ($80^{o}C$)	
1M	nil	nil	24-48 hours
5M	slight	slight	48 hours
6M	"	"	"
12M	some iron removal	more iron removed than in cold	cold 72 hours hot 4 hours

Although slight improvements were obtained in lightly stained areas of the blocks, heavily stained areas were little effected, even by boiling concentrated HCl.

2. The use of dilute hydrofluoric acid (HF) solution is recommended by Stambolov (1) for the removal of iron stain from siliceous stone in buildings, and seemed a suitable method for treating Batavia building blocks.

A piece of building block, with a moderately heavy iron stained surface, was immersed in 2% HF solution at 18°C and inspected at intervals to determine the progress of the reaction.

The removal of iron stain progressed slowly being completed in four days.

3. Complexing reagents are an obvious choice when removing stains resulting from transition metal compounds. Two reagents were tried; oxalic acid a fairly weak complexing compound, and ethylenediamine tetra-acetic acid tetra-sodium salt, (E.D.T.A.) - a strong complexing agent.

5% aqueous solutions of each complexing reagent were tested both hot (80°C) and cold (18°C), and with E.D.T.A. at pH's 4 and 13. (At pH4 the transition metal complexes are more soluble whereas at pH 12-14 the solubility of alkaline earth metal complexes is increased). The pH4 solution was produced by adding 30% acetic acid dropwise to 5% aqueous E.D.T.A solution.

Oxalic acid had only a slight effect on the staining even when warmed to 80°C and with prolonged immersion (eight days) at room temperature.

E.D.T.A. solution at pH 13 had little effect even at elevated temperatures, but at pH4 the solution was much more effective, removing moderately heavy staining, particularly at 80°C but not reducing very heavily stained or iron oxide encrusted areas to any noticable extent.

4. During the experiment with HCl of medium strength it had been noticed that where a sample of stone protruded above the surface of the liquid a diffuse green stain appeared around iron stained areas. This was thought to be due to HCl vapour penetrating the rock and dissolving out the iron as ferric chloride ($FeCl_3$).

To test this hypothesis a piece of moderately heavy iron stained sandstone was soaked in water and placed in a 4 litre beaker containing 50ml of concentrated commercial HCl. The beaker was covered with plastic film and gently heated to approximately 80°C on a hot plate. Within 30 mins the lightly stained areas were diffused away as $FeCl_3$ and heavily stained regions were much reduced in intensity. After one hour of treatment the light staining had disappeared and the heavily stained areas reduced to diffuse areas of $FeCl_3$, the latter being easily removed by washing.

Chemical tests on the diffuse areas showed iron to be present and in the ferric (Fe^{+++}) state, confirming the green stain as $FeCl_3$.

Soaking for a few hours in tap water removed the surface colouration, but did not remove the $FeCl_3$ from the inside since this appeared at the surface when the block was allowed to dry out. Longer soaking was found necessary, with occasional changes of wash water, until tests on the wash water, using ammonium thiocyanate test reagent, showed very low iron content. When dry the piece of block showed no signs of discolouration or iron stain.

The test was repeated with a heavily stained piece of sandstone with the same result. The process was then tried on one of the smaller, but complete, building blocks.

A polythene tank 1.5 x 1.0 x 1.0m deep was placed in a sunny position in the Laboratory yard. A number of house bricks were placed in appropriate positions on the bottom of the tank and the wet block placed on them. 1 litre of commercial HCl was introduced down the side of the tank to avoid putting acid directly on the block, and a sheet of clear polythene placed over the tank. This permitted heating of the acid by the 'glass-house' effect. The polythene sheet was maintained in position with wooden battens held down by house bricks.

Within 3 hours the light surface iron stain had begun to diffuse away as $FeCl_3$ and within 24 hours only the very heavy iron oxide encrusted areas still remained. After 36 hours all the iron oxide residue and iron stain had disappeared or were converted to $FeCl_3$.

The block was hosed down after removal from the tank and then placed in a second tank of tapwater to complete the washing process. The water was changed at intervals until tests for iron gave negligable results. At this stage the building block was removed from the wash tank and allowed to air dry. No further stains appeared on the surface of the block after standing for 2 months.

Conclusion

For the removal of iron stain in non-calcareous sandstone both hydrofluoric acid solution and hydrochloric acid vapour are satisfactory. However, hydrofluoric acid is slow in effect and dangerous to use particularly in large quantities.

The hydrochloric acid vapour technique is easy to use, even on a large scale, much less hazardous particularly if elementary safety precautions are taken and the acid used is cheap and easy to obtain. This method is also faster and can be checked visually for progress and completion. It penetrates throughout the material ensuring total removal of iron contamination

which is essential for outdoor display purposes.

It should be noted that the Stambolov method was designed to cope with iron stain on buildings i.e. surface stains, for which it is undoubtedly adequate. The technique used above for cleaning the building blocks may well be adaptable to cleaning iron stain on buildings provided the surface can be covered with plastic sheet and the HCl introduced in containers under the plastic.

References

(1) Bateson, C., (1972) Australian shipwrecks, 1, 1622 - 1850. Melbourne: Reed

(2) Stambolov, T., (1970) Conservation of stone in 'Conservation of Stone and Wooden Objects', Proceedings of the IIC New York Conference.

Acknowledgements

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ESSAIS DE TRAITEMENT SUR DES PIERRES ALTÉRÉES

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RESUME
Le Laboratoire de Recherche des Monuments historiques poursuit des recherches sur les procédés de traitement des pierres altérées.
SUR :
1) L'élimination des sels par immersion dans l'eau eau de ville, eau déminéralisée.
2) Nettoyage du marbre.
3) Application du procédé Lewin
4) Traitement par imprégnation de monomère et polymérisation au rayon gamma
5) Etudes comparatives des divers traitements.

Dans le cadre des recherches des traitements des pierres le L. R. M. H. poursuit deux grandes lignes de recherches : Traitements préventifs, traitements curatifs. Les traitements préventifs sont étudiés en collaboration avec le C. E. B. T. P. et le C. R. E. O. : hydrofuge, lutte contre les remontées d'eau. Les divers traitements curatifs sont testés dans une salle d'essais des matériaux du L. R. M. H. et in situ sur des édifices.

I - EXTRACTION DES SELS SOLUBLES PAR IMMERSIONS

1) Extraction des sels solubles à l'eau de ville sur les calcaires

L'extraction des sels solubles a été faite sur des balustres en calcaire de l'Oise de Saint-Antoine de Compiègne. Les altérations des pierres se manifestaient par :

a) une érosion notable des parties saillantes
b) une accumulation de gypse et de suies sur les parties non lessivées par les pluies.

Ces pierres sulfatées ont été traitées par immersion dans l'eau courante de ville.
Pour cela des cuves de bois recouvertes de plastique ont été construites (2 m x 2 m x 0,70 m de haut). Dans ces cuves l'eau de ville circulait librement.
Le Laboratoire a suivi les divers stades du traitement en faisant des prélèvements à la surface de la pierre et en les analysant en spectrographie infra rouge.
Durant la première semaine, la couche noire de suie et de gypse s'est ramollie. Cette dernière a pu être éliminée par un brossage léger à la brosse de nylon.
La pierre a retrouvé alors sa couleur initiale.

Il restait à suivre la disparition des sulfates. Pour cela 7 zones ont été délimitées sur le balustre : (1,50 m x 1,50 m x 0,40 m d'épaisseur). Des prélèvements répétés toutes les semaines ont été effectués. Ces échantillons étaient très petits (des têtes d'épingles) et étaient pratiquement non destructifs.

Dans chaque zone, les spectres obtenus au cours des diverses phases, ont été superposés : On constate au bout de trois semaines d'immersion dans l'eau de ville, que le pic des sulfates a disparu (Diagramme I). La roche avait repris sa couleur initiale.

(Des essais de durcissement ont été faits par immersion sur des éprouvettes de la même roche. Les produits testés étaient des silicates, des fluosilicates et des polymétacrylate de méthyle. Des mesures effectuées, il ressortait que l'amélioration de la dureté n'était réelle que dans les premiers millimètres. Cette croûte dure ainsi formée, aurait donc empêché la respiration de la pierre. Aussi ces divers procédés n'ont pas été utilisés pour le traitement des balustres).

2) <u>Extraction des sels solubles à l'eau déminéralisée sur un calcaire</u>

Sur un balustre déposé de l'église Saint-Jean de Dijon, atteint de desquamations et de noircissement, nous avons procédé à l'élimination des sels à l'eau déminéralisée.
Pour cela, le L. R. M. H. possède une salle d'essais de matériaux qui est équipée d'une station de traitement des eaux de rivière (Marne). On obtient ainsi de l'eau industrielle à bon marché et de l'eau déminéralisée.
Pour l'immersion nous avons utilisé des bacs en plastique de 2 m x 2 m x 0,70 m.

La première immersion a été faite à l'eau industrielle (non renouvelée) pendant 1 semaine. Au bout de ce temps la couche de suie et de gypse a disparu avec un léger brossage.
Puis pendant 3 semaines le balustre a été immergé dans 3 bains successifs d eau déminéralisée. Le p.Hde cette eau était de 5,5 et la résistivité de 500.000 Ωx cm.
Afin de faciliter la dissolution des sulfates l'eau était agitée en permanence.
Entre chaque période d'immersion, on a fait des prélèvements pour réaliser des spectres infra rouges. Comme précédemment en superposant les pics des spectres, on a pu constater que le calcaire avait perdu la totalité de ses sulfates au bout de 3 bains d'eau déminéralisée d'une semaine chacun.
Après ces immersions, on a laissé sécher la pierre et l'on a pu constater que cette dernière reprenait sa dureté.
De plus on n'a pas constaté l'apparition d'efflorescence de sulfate. Des prélèvements ont été effectués sur la pierre sèche, et l'analyse chimique a montré qu'il n'y avait plus de sulfate.

3) <u>Elimination des sels solubles à l'eau déminéralisée sur un Grès</u>

Sur un grès à ciment calcaire, église de Thann (Alsace), nous avons procédé à une élimination de sel à l'eau industrielle et à l'eau déminéralisée. Nous avons procédé aux expériences suivantes :

1ere phase - Immersion à l'eau industrielle + brossage

2eme, 3eme, 4eme phase - Immersion d'une semaine dans de l'eau déminéralisée.

Comme précédemment nous avons pu constater sur les divers spectres réalisés dans la même zone, la disparition du pic des sulfates. Après séchage, le grès avait repris sa couleur initiale et sa dureté.
Par immersion de pierre calcaire et de grès dans de l'eau de ville et dans de l'eau déminéralisée, nous avons donc pu éliminer les sulfates qui sont les principaux sels causant les altérations des pierres.

II - <u>ESSAIS DE NETTOYAGE</u>

A la demande du Musée du Louvre, nous avons essayé les procédés de nettoyage : le procédé Mora et le procédé d'application d'Attapulgite, sur une pierre de marbre saccharoïde. Au bout de 15 jours en changeant périodiquement les applications le marbre a retrouvé son coloris

original.
Ces deux procédés ont été testés sur le portail en marbre de Saint Gilles du Gard. Seul, le procédé Mora a donné de bons résultats après une application d'une journée et un lavage abondant à l'eau de ville.

III - TRAITEMENT SELON LE PROCEDE S. A. LEWIN

Sur une statue de calcaire de Belbeze (1,30 m) qui était pulvérulente et sulfatée, le procédé Lewin a été utilisé.
La statue a été immergée dans un bain d'hydroxyde de Baryum et d'urée à une température maintenue à 70° C. Ce traitement a duré 1 semaine. Puis la statue a été rincée à l'eau industrielle. Après séchage la pierre qui était pulvérulente est redevenue très dure. Le calcaire qui était blanc a subi par endroits une variation de teinte due à des dépôts.
Nous l'utiliserons en 1975 avec des pierres de porosités et de porométries différentes pour mesurer les améliorations de leurs caractéristiques physiques à diverses profondeurs. Ces mesures seront réalisées en collaboration avec le C. E. B. T. P.

IV - TRAITEMENT DE LA PIERRE PAR IMPREGNATION DE MONOMERE ET POLYMERISATION AU RAYONNEMENT GAMMA

Les recherches du C. E. N. G. sur l'imprégnation de monomère et polymérisation aux rayons gamma sont menées dans le cadre de nos études sur le traitement des pierres et font l'objet d'une communication spéciale (groupe d'application de méthodes nucléaires).

V - ETUDES COMPARATIVES DES DIVERS PROCEDES DE TRAITEMENT DES PIERRES ALTEREES

Sur le portail Sud de l'église Saint Philibert de Dijon en calcaire, nous allons appliquer les divers procédés de traitement.
En premier lieu, il y aura une étude approfondie sur la nature de la roche (dureté, porosité, porométrie, résistance à la compression, mesure de la vitesse du son, résistance au gel).
Ensuite il sera réalisé les traitements suivants :
1) Sur pierres déposées : Déminéralisation à l'eau osmosée, traitement par le procédé Lewin par immersion à chaud, imprégnation à l'aide de monomère et polymérisation par rayons gamma C. E. N. G.
2) In situ : le procédé Domaslowsky

Après ces traitements, on étudiera les nouvelles caractéristiques des matériaux traités et leur tenue dans le temps.

VI - CONCLUSION

Les procédés préventifs sont testés par nous en collaboration avec le C. E. B. T. P. et le C. R. E. O. : Hydrofuges, lutte contre les remontées d'eau.

D'autre part, au L. R. M. H., les pierres altérées sont traitées avec les divers procédés "curatifs" connus, et l'on effectue les mesures des diverses caractéristiques des pierres traitées. Après les études commencées en laboratoire, nous ferons des applications in situ sur les édifices.

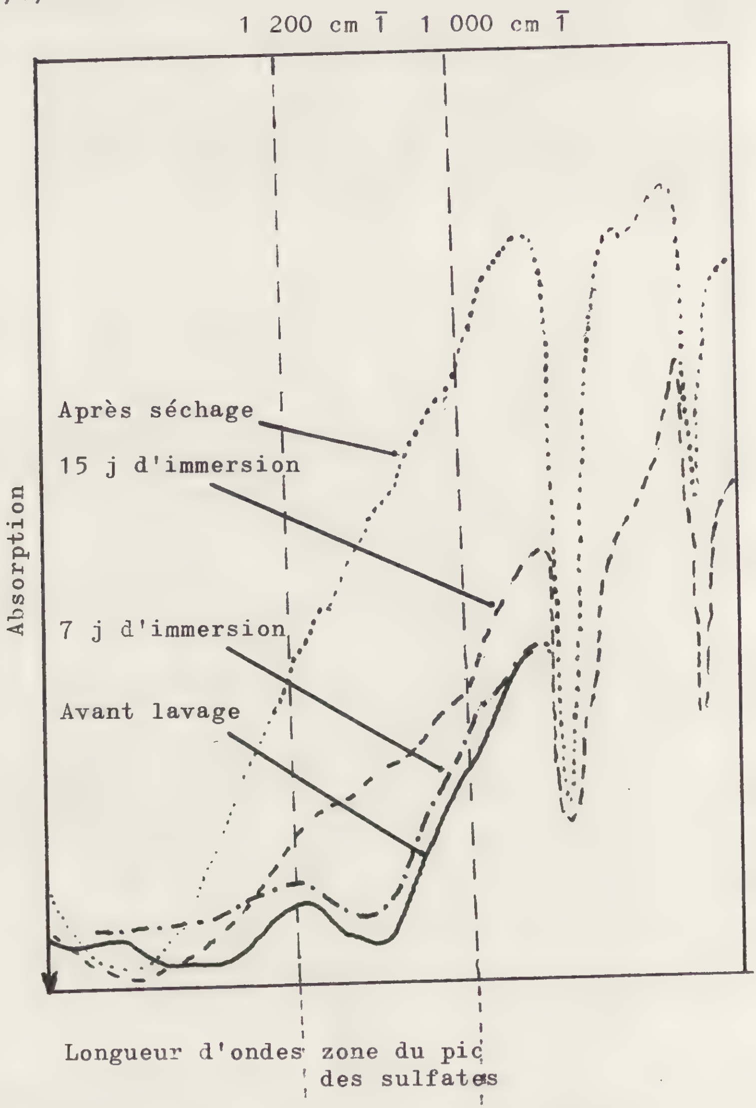

DIAGRAMME 1 : Elimination de sels par immersion dans de l'eau déminéralisée. Exemple de comparaison de spectres infra rouges montrant la regression du pic des sulfates en fin de traitement.

EXFOLIATION OF STONE SCULPTURES: REVIEW OF RESEARCHES CARRIED OUT ON ITALIAN MONUMENTS WITH PARTICULAR REGARD TO THE RELIEFS BY WILIGELMO ON THE CATHEDRAL OF MODENA

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Summary

Experimental researches carried out on sandstones and marble showing decay by exfoliation, demonstrated that the alteration mechanism mainly consists of the dissolving of calcitic cement, or of the edges of the calcite granoblasts, made by acid water, followed by crystallisation near the surface of the new-formed salts. The repetition of the process leads to the formation of a hard surface skin with loss of cohesion of the underneath stone; the skin loses its support and starts exfoliating.

Carbon dioxide was sufficient, as an acid agent, in the past, to bring about an advanced decay by edfoliation in bad quality stones such as the sandstones studied.

Concerning marble, this type of decay was only observed in marbles that at the beginning of the industrial pollution had already endured centuries of natural weathering. Marbles that were new around that time and marbles that before that time were placed in a museum show still a compact surface.

The phenomenon of the exfoliation can however also be observed in stones in a good state of preservation. Treatments carried out, perhaps last century, with mixtures based on calcium hydroxide, formed on carved surfaces hard skins which to-day, before analysis, were taken for an indication of decay.

The skins formed by those treatments contain now, in

general, 50-70% gypsum; in cross section they appear clearly superimposed on the stone, still compact and with its surface perfectly outlined.

On the contrary, surface skins formed by decay are not sharply divided from the underlying stone, since the stone structure is changing gradually from the inner to the outer zone. Moreover the decay skins were found to contain at the most 25% gypsum, in the worst condition.

Résumé

Des recherches expérimentales conduites sur grès à ciment calcaire et sur marbre, détériorés par exfoliation, ont montré que le procedé d'altération consiste surtout dans la dissolution du ciment des grès ou des bords des granoblastes de calcite du marbre par action d'eaux acides, suivie par la cristallisation en surface des sels néoformés. La répétition du procédé conduit à la formation d'une croûte superficielle et à la perte de cohésion de la pierre de dessous et ensuite à l'exfoliation de la croûte.

L'anhydride carbonique a été suffisante, comme agent acide, dans le passé, pour provoquer une détérioration par exfoliation, assez avancée, dans le cas de pierres de mauvaise qualité comme les grès étudiés.

En ce qui concerne le marbre, ce type d'altération a été observé uniquement sur les marbres qui au début de la pollution industrielle avaient déjà subi des siècles de vieillissment naturel. Des marbres qui à cette époque étaient neufs ou des marbres qui avant cette époque avaient été transportés dans le musée présentent encore aujourd'hui des surfaces compactes.

Le phénomène d'exfoliation a pu être observé également sur des pierres en bon état de conservation. Des traitements exécutés, peut-être durant le siècle dernier, avec des mélanges à base de chaux, ont créé sur les surfaces sculptées des croûtes, qui aujourd'hui, avant d'être analysées, avaient été considérées comme un indice d'altération.

Les croûtes dues à ces traîtements contiennet maintenant, en général, 50-70% de gypse; en section transversale apparaîssent nettement superposées à la pierre, qui

est restée compacte et avec une surface parfaitement délinéée.

Au contraire, les croûtes superficielles, dues à la dégradation, ne sont pas nettement divisées de la pierre de dessous, du fait que la structure de la pierre change graduellement depuis l'intérieur vers l'extérieur. En outre, les croûtes d'altération contiennent au maximum 25% de gypse, dans les pires conditions.

INTRODUCTION

The decay of stone by exfoliation associated with the formation of a hard surface skin is a phenomenon frequently observed in monumental stone.

The phenomenon of the exfoliation can however also be observed in stones in a good state of preservation. In these cases the surface crust tending to blister and scale was found to originate from materials deposited on the surface by treatments carried out on the carved stone, probably with the purpose of protection.

In the light of the results of experimental studies the differences between the two kind of surface skin peeling are discussed.

EXFOLIATION BY ALTERATION OF THE STONE

The decay of stone by formation of a hard surface skin tending to blister and exfoliate has already been a subject of discussion for a long time. Several processes are considered responsible for the surface hardening while the successive fall of the surface skin is attributed to various causes (1, 2, 3).

Torraca (4) tried to simplify the situation by considering only those explanations which in his opinion are the most significant for the interpretation of the deterioration phenomenon. He formulated a "model" based on the "moisture rhythm".

According to this model, deterioration of the kind we are discussing is attributed to repeated wetting and drying combined with the attacking of the grain cement

by acid water and the subsequent crystallization at or near the surface of the soluble salts formed in the reaction. Therefore the hardening of the surface is carried out at the expense of loss of cohesion of the underlying stone. The skin loses its support and starts exfoliating.

The results of experimental studies carried out on different kind of stones showing decay by exfoliation - sandstone of monuments in Bologna and marble of monuments in Siena - are in agreement with the Torraca model.

Sandstone ornamentation in Bologna

In the case of the sandstones, with calcitic cement, used in the Renaissance ornamentations of the Bologna monuments, we performed extensive analyses: petrographic, X-ray diffraction, and chemical determination of carbonates, sulphates and most of the cations present (5). All these analyses were carried out both on the surface crust and the uncohesive underlying layer as well as on the sound core of the stone.

The results of this study have shown that the disintegration of the stone under the crust is mainly due to an acid attack on the calcitic cement, while the formation of a hard surface skin is mainly caused by crystallization near the surface of the new-formed calcite and gypsum.

The absence of gypsum in the sound stone excludes the hypothesis that the formation of the skin is due to a concentration at the surface of soluble salts already present in the original stone.

Furthermore it was shown how in the case of poor quality stone like the Bologna sandstones, the moisture rhythm and the following exfoliation brought about an advanced state of deterioration of the stone even in the absence of sulphuric acid, the presence of atmospheric carbon dioxide being already sufficient. This is also clear from pictures taken last century.

Marble monuments in Siena

In the subsequent study of the Siena marble (6) it was found that the Torraca model is also able to account for the deterioration by exfoliation in the case of stone that does not contain the calcium carbonate in the easily chemical attacked form of a cement. In this marble the process proceeds by dissolution of the edges of the calcite granoblasts.

This research was carried out on monuments of which the marble was always of the same origin but that had been exposed to the open air for different periods of time.

The results obtained in this way enables one to evaluate the effect of atmospheric pollution. An advanced state of deterioration by exfoliation is only observed on those marbles that at the beginning of industrial pollution had already a surface rich in pores and microfissures caused by centuries of natural weathering. Marbles that were new around that time and marbles that before that time were placed in museum still show a compact surface. The situation is clearly illustrated in Fig. 1 and 2.

Fig. 1 shows the photomicrograph of a thin section of a chip taken from the surface of a statue which was originally on the 13th century façade of the Siena cathedral but placed in a museum about eighty years ago. No structure or mineralogical modification of the crystalline marble is observed. The dark film on the surface contains oil, as shown by the thin layer chromatography; and is probably due to an old protective treatment. Note the sharp separation between film and stone. Neither the film nor the stone surface contains gypsum, except traces, as shown also by X-ray diffraction patterns and chemical analysis of sulphates.

Similar results emerged in the case of the copy of the "Fonte gaia" which was new a century ago when it substituted the original by Jacopo della Quercia in the Siena Campo square. Here also the surface, still compact, does not show any structure or mineralogical modification of the crystalline marble. It does not contain gypsum but is covered by a very thin skin, consisting mainly of calcite, sharply separated from the underlying stone.

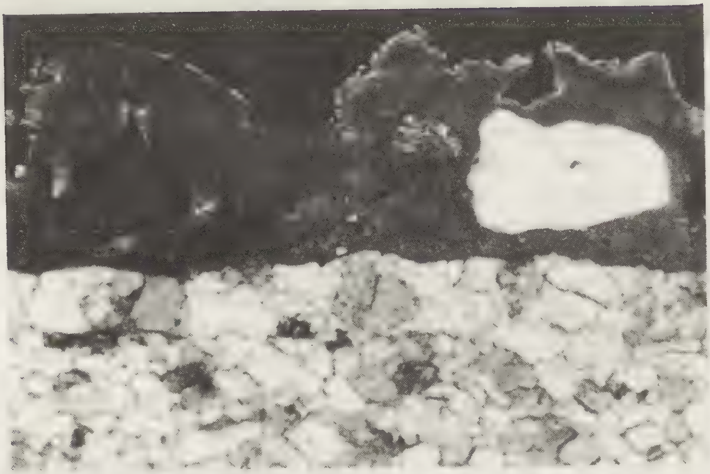


Fig. 1 - Photomicrograph of thin-section of a sample from the surface of a statue formerly on the Siena cathedral, since 1890 in the Museum. Crossed polarizers. 95 x magnification.

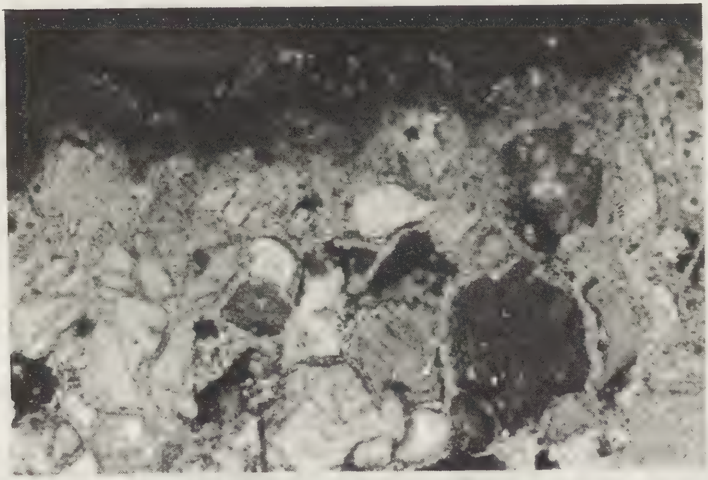


Fig. 2 - Photomicrograph of thin-section of a sample from the surface of a capital of the Siena cathedral. Crossed polarizers. 210 x.

The situation is completely different in the case of the capitals of the cathedral that show an advanced state of decay by exfoliation: neraly everywhere the hard surface skin covers a stone layer completely without cohesion. This is illustrated in Fig. 2 where a photomicrograph of a thin section of a sample taken from one of the capitals is shown. At the surface the granoblasts of calcite can still be recognized but they clearly show the effect of dissolution and intergrain cementation. The cementing minerals are calcite and gypsum, the last one is particularly abundant near the exterior brown film, which also in this case originated from an old protective treatment, as it contains oil.

The results of this examination under the microscope, as well as of X-ray diffraction and chemical analysis carried out on the surface skin and the underlying uncohesive layer, confirm the hypothesis that the moisture rhythm is responsible for the decay process. In fact the small quantity of gypsum in the uncohesive layer (3% or less), the higher quantity of this salt in the surface skin (about 10%), as well as the observation that in the skin the amount of gypsum increases going from inside to outside while the amount of the newformed calcite is decreasing, is what one should expect: on evaporation the less soluble salts (in this case calcite) formed in the dissolution process of the granoblasts deposit first while the more soluble gypsum tend to deposit in the more external layers.

The experimental results also allow one to reject the hypothesis that the fall of the surface crust is caused by the crystallization of gypsum along the edges of the granoblasts (7) or by volume increase of the calcium sulphate in the process of hydratation (8). This can be concluded from the observation that gypsum is more abundant in the crust, where it acts as a cement, than in the underlying friable zone. Furthermore from the fact that the small quantity of this mineral in this zone occurs in the form of intergrain cement instead of single crystals; this shows that it is directly precipitated from the circulating solutions and is not formed by hydratation of a preceeding anhydric fase.

At this point we like to emphasize that in a stone deteriorated by the formation of a hard surface skin the

structure changes gradually going towards the surface. The surface skin still contains components of the original stone and there is not a sharp boundary between the crust and the underlying stone.

The situation is completely different from the phenomena encountered in the Wiligelmo reliefs that we are going to discuss now.

EXFOLIATION OF SURFACE SKIN FORMED BY TREATMENT OF THE STONE

Reliefs by Wiligelmo on the façade of the Modena cathedral

Some years ago A. Mezzetti (9) published an interesting study based on a comparison of pictures of these reliefs taken during the last sixty years. The more recent pictures showed extensive exfoliation when compared with the older ones. The author concluded that there was a rapidly increasing decay of the sculptures (9, 10).

The study we carried out on these reliefs leads to a completely different conclusion, as will presently be shown (11).

The first suggestion in a different direction came from the observation of the reliefs at a close distance: a hard black skin appears to cover the reliefs. On the two lower reliefs this skin can reach the thickness of almost a millimeter, it can easily be detached by hand and shows on its reverse a perfect impression of the relief underneath (Fig. 3). On the two upper reliefs the skin is thinner and sticks tightly to the stone. In all four reliefs, under the skin, the stone appears compact; it looks well preserved and in some areas shows residues of a probable original policromy.

Many samples were taken from the reliefs. Examination of the thin sections and polished sections under the microscope, X-ray diffraction analysis, chemical analysis and thin layer chromatography were carried out with the aim of investigating the state of preservation of the stone and to determine the nature of the surface skin.

Fig. 3 - Skin formed by treatment; taken from the left lower relief by Wiligelmo; photographed on its reverse side. A perfect impression of the carved stone underneath can be observed.

Fig. 4 - Photomicrograph of thin-section of a sample from the left lower relief by Wiligelmo. Surface skin and stone underneath. 130 x.

Nature and preservation of the stone - From the results of the petrographic analysis, the stone of the reliefs is shown to be an organic compact limestone. The skeletal part of animals makes up about 50% of the rock. They are well recrystallized during diagenesis and are cemented by a matrix mainly consisting of carbonates.

Furthermore the observation under the microscope of thin sections with transmitted light showed that the structure does not change gradually going from the inner zone to the outer dark skin, as was observed in the case of the samples from the capitals of the Siena cathedral. On the contrary in the present case the dark surface skin is clearly superimposed on the stone surface and a sharp division is observed between the skin and the stone surface (Fig. 4).

The observation under the microscope of cross-sections in reflected light supports the above conclusion. The stone appears still compact, with its surface perfectly outlined and clearly distinct from the skin on top (Fig. 5).

The X-ray diffraction patterns of samples taken from stone layers of less than 1 mm thickness just under the surface skin, showed the presence mainly of calcite, but also of a small quantity of gypsum (Fig. 6). The chemical analysis of sulphates carried out with a spectrophotometric methods (12) provided other, more quantitative evidence, of the presence of gypsum in the outer surface of the stone, just under the skin.

The results of chemical analysis as well as the X-ray diffraction patterns also showed an increase in the amount of gypsum in the areas of the reliefs where the skin has already disappeared.

In conclusion it can be safely stated that the deterioration process by conversion of calcite into gypsum can be in an advanced state in the areas of the reliefs that are deprived of the surface skin. This process will have already started under the skin, as this in its uncomplete state does not represent anymore a barrier against the penetration of water.

The sulphate attack on the stone, however, is not responsible for the formation and the exfoliation of the hard surface skin. This is demonstrated by the obser-

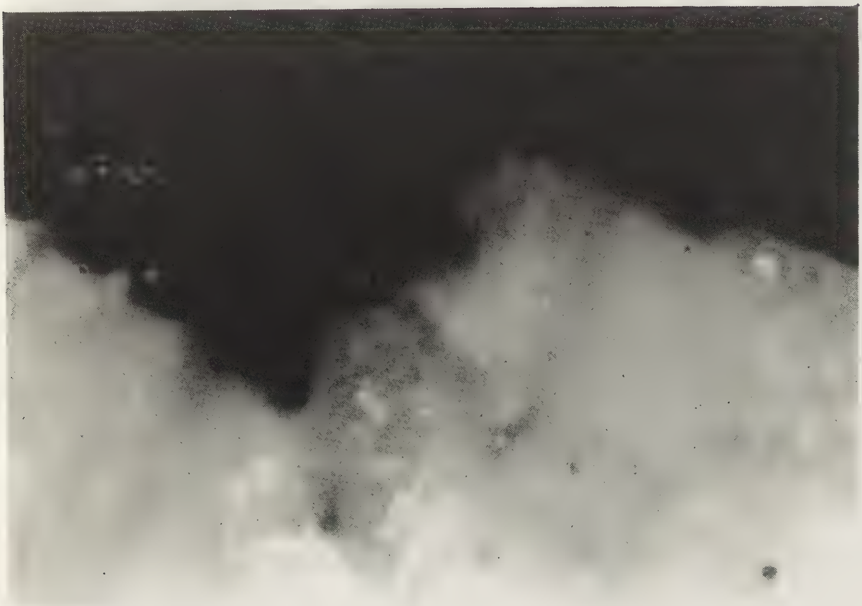
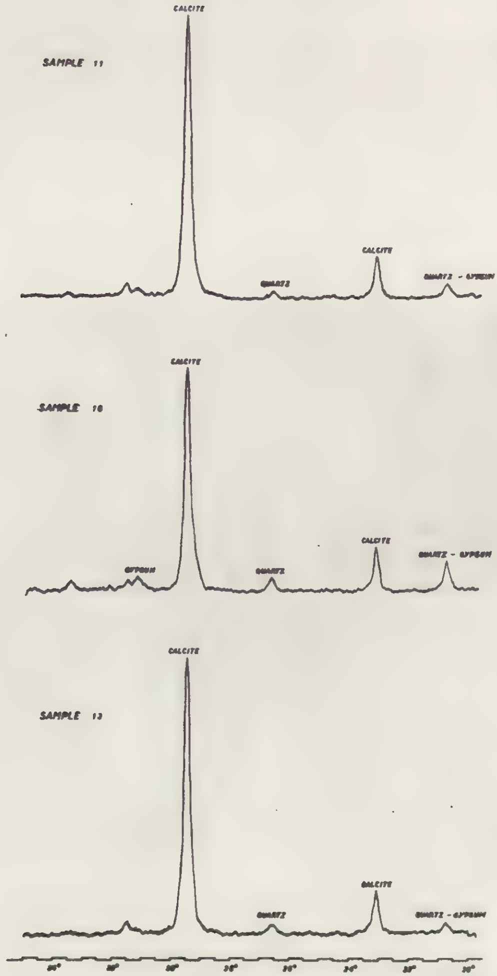


Fig. 5 - Photomicrograph of cross-section of a sample from the right lower relief by Wiligelmo. Surface skin and stone underneath. By reflected light. 145 x.



<u>Fig. 6</u> - X-ray diffraction patterns of stone samples from the Wiligelmo reliefs.
Sample 11: taken inside a fissure at 1 cm from the surface. Sample 16: scraped from just under the surface skin. Sample 13: scraped from the stone surface in an area where the skin has already disappeared. Diffractometer Rigaku-Denkj. Radiation Cu Kα.

vation carried out "in situ" as well as by the examinations under the microscope. The same conclusion can also be reached indirectly when we take into account the fact that the surface skin was shown to consist of up to 50-65% gypsum, as will be discussed later. If all the calcium contained in this great amount of gypsum had come from the underlying stone, this stone would certainly have shown an advanced state of deterioration and no longer be compact with its surface perfectly outlined.

<u>Composition and genesis of the surface skin</u> - The composition of the surface skin which cannot have its origin in the deterioration of the underlying stone, suggests that it must derive from old treatments.

Microscopic study of the cross-sections shows that the skin from the two lower reliefs consists of three layers (Fig. 7 and 8) which from inside to outside can be described as follows:

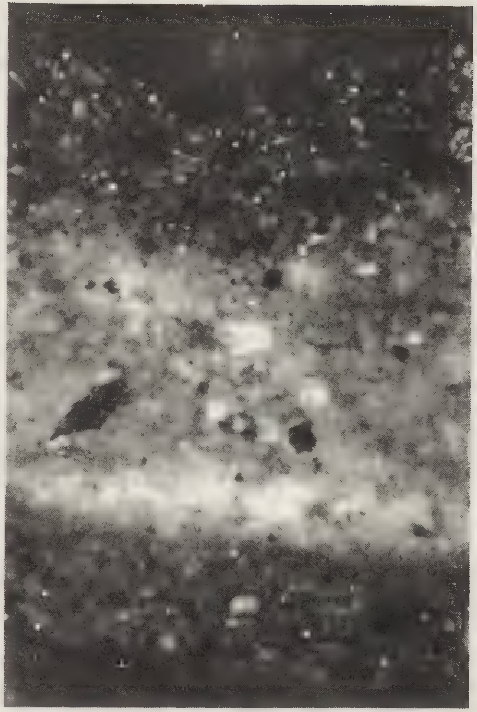
a) The first layer (I) is grey-brown, finely grained and rather uncohesive. It is dark under U.V. light.

b) The second layer (II) is light brown, coarser grained in comparison with layer I. Under U.V. light it becomes fluorescent.
Both layers I and II contain gypsum, iron oxides and a few carbon particles.

c) The third layer (III) is black and is probably due to deposits of dust and soot; in fact its thickness changes very much from a few carbon particles to 0.2-0.5 mm depending on the orientation with respect to the vertical of the area where the sample came from.

From examination of the cross-section of the skin covering the two upper reliefs it appears that in this case layer I is not present while layers II and III have the same characteristics as described above (Fig. 9 and 10).

X-ray diffraction patterns demonstrated that both layers I and II contain calcite, quartz and a great amount of gypsum; those patterns also showed that the gypsum content increases in layer II with respect to layer I while the calcite content decreases (Fig. 11). More



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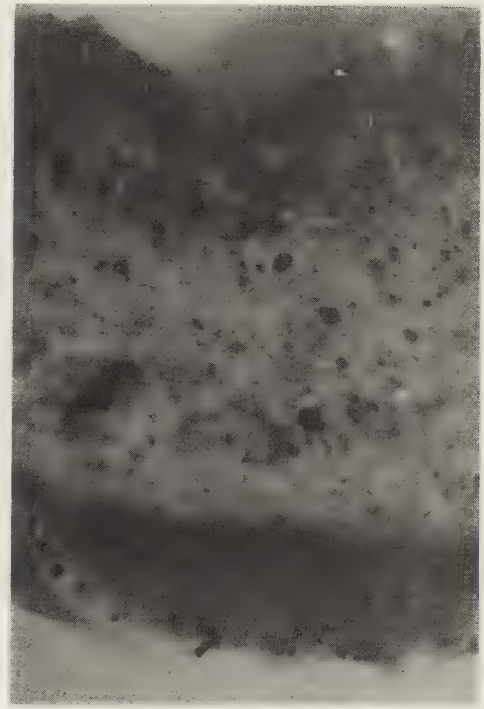

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<u>Fig. 7 and 8</u> - Photomicrograph of cross-section of the surface skin formed by two treatments. Sample from one of the lower Wiligelmo reliefs.
Fig. 7 by reflected visible light. Fig. 8 by fluorescence. 145 x.

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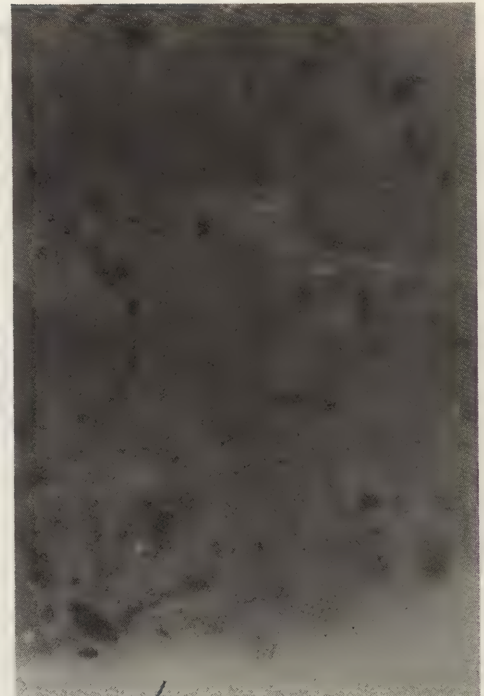

<u>Fig. 9 and 10</u> - Photomicrographs of cross-section of the surface skin formed by only one treatment. Sample from one of the upper Wiligelmo reliefs.
Fig. 9 by reflected visible light. Fig. 10 by fluorescence. 145 x.

exactly, from the figures obtained from the chemical determination of sulphates, layer I was shown to consist of up to 30% gypsum and layer II of up to 50-60% gypsum.

The results obtained from the analysis carried out in the attempt to find the presence of organic substances in the skin, allowed us to exclude the presence of proteins but they showed that oil is contained in the second layer of the crust. Note that this is the one that is found to cover the surface of all four reliefs.

This last result is illustrated in Fig. 12, which shows the thin layer chromatograms obtained under the conditions indicated. We see that the chromatograms of the chloroform extract of layer II, apart from hydrocarbons probably originating from smog, show the presence of triglycerides and fatty acids, all oil components. Layer I, as well as layer III not shown in the figure, contains neither triglycerides nor fatty acids.

Besides oil, layer II contains other substances not separated by the developing method used here and appearing in the chromatograms as a continuous fluorescent streak. Therefore a comparison was carried out with several natural resins and also with a chloroform extract of soot, using more polar developing systems which better separate the fluorescent components of the samples under analysis. The results obtained enable us to conclude that some smog components are present probably as well as turpentine.

The results of the experimental investigation carried out on the skin support the conclusion previously stated that the surface skin was formed by substances purposely deposited on the carved surface, perhaps for protection. We come to the following probable conclusion.

A first treatment with a mixture which provided a fair amount of the calcium now contained in layer I was extended to the lower reliefs only. It resulted that layer I contains calcite, about 30% gypsum, quartz, iron oxides and no organic compounds, therefore the material deposited on the carved surface in the course of this first treatment probably was mainly calcium hydroxide with the addition of some red iron pigments and, perhaps, of sand; in the atmosphere calcium hydroxide was

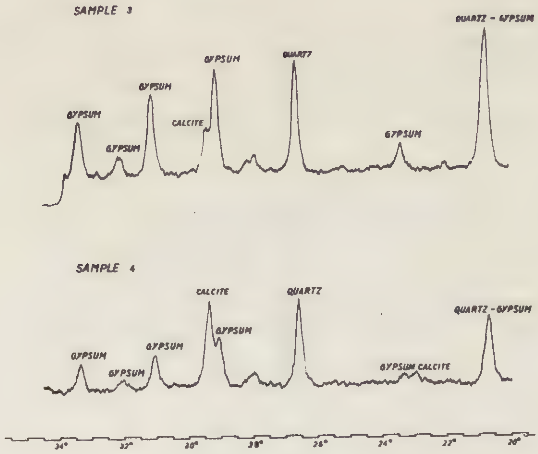

Fig. 11 - X-ray diffraction patterns of the surface skin from the lower Wiligelmo reliefs. Sample 3: layer II of the skin (2nd treatment). Sample 4: layer I of the skin (1st treatment).
Diffractometer Rigaku-Denkj. Radiation Cu Kα.

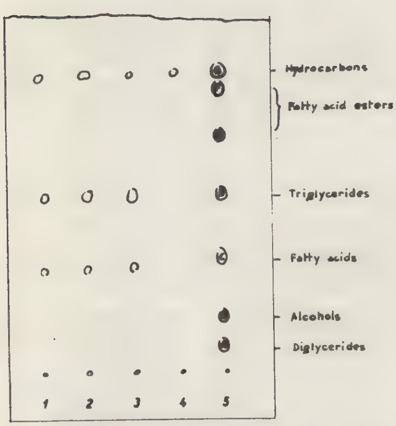

Fig. 12 - Thin-layer chromatograms of chloroform extracts of skin samples from the Wiligelmo reliefs. Stepwise development. Solvent: 1. step, petroleum ether (B.P. 30-60°C)-ethyl ether-acetic acid (70:30:1), 6 cm run; 2. step, petroleum ether (B.P. 30-60°C)-ethyl ether-acetic acid (90:10:1). Visualisation: exposure to iodine vapors then 2'7'-dichlorofluorescein 0.1% in ethanol.

1: layer II (from the right lower relief); 2: layer II (from the right upper relief); 3: layer II (from the left lower relief); 4: layer I (from the left lower relief); 5: artificial mixture (A: 1-2 dipalmitin; B: stearyl alcohol; C: stearic acid; D: tripalmitin; E: palmitic acid methyl ester; F: stearic acid stearyl ester; G: squalene.

converted into calcium carbonate and subsequentely into calcium sulphate.

A second treatment was then extended to all four reliefs. It is responsible for the formation of layer II in the surface skin. This treatment was probably carried out with an inorganic mixture similar to the one previously applied but also containing oil and probably turpentine.

The portals of the St. Petronio church in Bologna

A situation similar to that encountered in the Wiligelmo reliefs emerged in the case of the 15th century sculptures by Jacopo della Quercia in the main portal of St. Petronio's church as well as in the 16th century sculptures in the lateral portals of the same church in Bologna.

The appearance of white spots on the black surface of the Jacopo reliefs caused great alarm regarding the state of preservation of these sculptures. One was afraid that a crust due to alteration could be starting to exfoliate.

The research we carried out on the Jacopo portal, which later on we extended to the lateral portals which also are covered by a black skin starting to exfoliate, have already been published (13, 14, 15) and we will give here only the main conclusions.

What is exfoliating from the sculptures of the St. Petronio portals is not a crust which has its origin in the deterioration of the underlying stone but it is a hard skin mainly formed from a non-original treatment.

In the Jacopo portal, under the surface skin the carved stone (a sedimentary limestone as resulted from our petrographic analysis, in accordance with documentary information) is well preserved. The stone is still compact with its surface perfectly outlined; the surface contains no gypsum. Moreover an original protective film, containing beeswax, natural resin and perhaps "rue oil", is still surviving on the carved surface, under the skin derived from a later treatment.

In the lateral portals some localized damages, such as

the fall of a few prominent parts of the sculptures, can be observed. This is obviously due to penetration of water through fissures or microfissures. Apart from this, the carved stone, marble in this case, also appears here compact and not deteriorated under the surface skin derived from a later treatment.

The hard surface skin on both the major and the lateral portals come from the same treatment because the composition of the skin results to be the same. It contains red iron oxide, about 55% gypsum, 2-3% calcite, and casein, as resulted from the X-ray diffraction patterns, chemical analysis and thin layer chromatography of the amino acid dansyl-derivatives. It contains also traces of oil. It seems unlikely that oil and casein were present together in the mixture used for the treatment. It is probable that the sculptures received an additional later protective treatment with oil alone.

Sandstone reliefs in the Podestà Palace in Bologna

The two kinds of surface skin peeling discussed above can both be seen on the sandstone reliefs on the Podestà Palace in Bologna.

These reliefs, as well as most of the sandstone ornamentations on the Palaces and Churches in Bologna, are in a state of advanced decay and show everywhere hard surface scales as reported above.

On the reliefs of the Podestà Palace, however two types of scales can be recognized as shown in Fig. 13. The scales which have their origin in the deterioration process are visible everywhere in this picture. Apart from them in the indicated area a skin is observed which shows a regular cracquelé and is due to a protective treatment as will presently emerge.

The stone underlying the deterioration skin appears very crumbly while the skin due to a treatment covers a comparatively compact stone. Moreover in cross-section (Fig. 14) this last skin appears separated from the underlying stone by a thin black line, probably due to dust and soot covering the surface at the time the treatment was carried out.

This "artificial" skin was analysed and resulted to con-

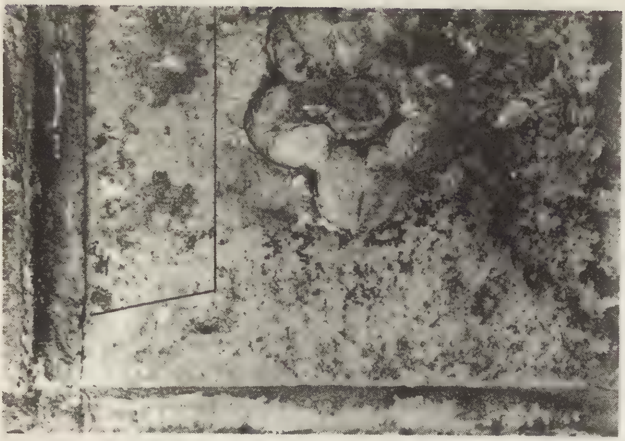

Fig. 13 - Particular of the sandstone reliefs on the Podestà Palace in Bologna. Scales by decay and, in the indicated area, scales of a skin formed by treatment.

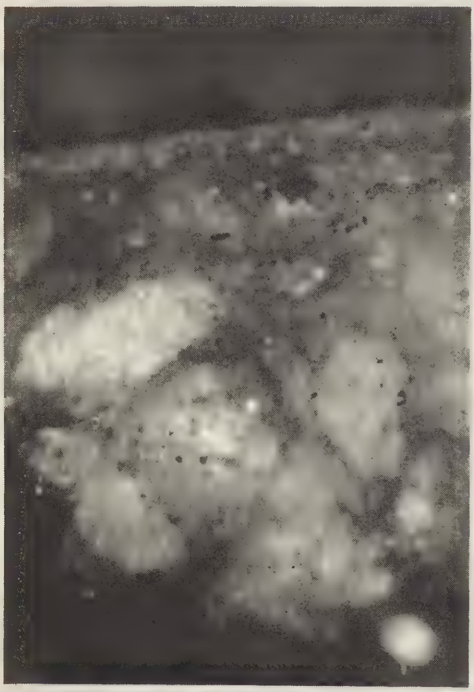

Fig. 14 - Photomicrograph of cross-section of a sample from the Podestà Palace in Bologna. By reflected light. 145 x.
The upper layer (thickness 90-140 μ) is the skin formed by treatment.

sist of more than 70% gypsum. It also contains an iron red pigment of the sienna type; it does not contain organic substances, as resulted from analyses carried out in order to determine the presence of proteins, oil, waxes and natural resins. Moreover it only contains traces of calcite.

The very high quantity of gypsum can be compared with the lower gypsum content (20%) of the deterioration crusts in the same reliefs. This comparison provides further support to the hypothesis that the two types of scales have different origins.

The very high content of gypsum and the absence of calcite in the skin suggests that, at least in this case, the mixture applied to the reliefs' surface already contained gypsum.

CONCLUSION

In conclusion, it may be fairly claimed that exfoliation of stone sculptures does not necessarily indicate a deterioration of the stone. The results of the studies reported here emphasize the importance of investigating how a hard skin may have arisen when found covering the surface of ancient stonework. A blistering and exfoliating skin can have its origin either in the stone decay with the mechanism illustrated in the Torraca model, or in later additions provided by treatment of the carved surface, probably with the purpose of protection.

Concerning the composition of the mixtures used for carrying out those treatments forming the hard skins we have studied, it can be stated that the minor components were iron oxide pigments, perhaps sand (on account of the presence of quartz) and sometimes organic substances such as oil or products containing casein. The main component was always a calcium compound, probably calcium hydroxide which was converted to calcium carbonate, then to calcium sulphate by reaction with the atmospheric pollutants.

At this stage it can be pointed out that skins due to a treatment were shown to contain, generally, more than 50% gypsum, while the skins formed by decay of the stone resulted to contain much lower quantities of this salt

(10% in the case of the Siena marble; 5-25% in the case of the Bologna sandstones). Sulphate attack is certainly easier carried out on those artificial skins similar to a plaster, than on a natural stone. However the hypothesis of gypsum already being contained in the mixture applied to the stone surface cannot be excluded, particularly when the skin was found to contain as much as 70% gypsum and only traces of calcite.

Gypsum is not quoted among substances used for the treatment of stone published last century, of which we will discuss here below; but it is said that it was used for this purpose in Emilia and in Tuscany.

It is hard to say when these types of treatments forming a hard skin on the stone surface were carried out. But it can be remembered that many of the methods for the protection of stone published last century (16) suggested coating mixtures containing lime and also other substances such as sand, carbon, oil, sugar, etc. These mixtures were evidently intended to form a kind of plaster similar to the hard skins which are found to-day covering sculpture surfaces.

Regarding this it can be said that during a last visit to the Wiligelmo reliefs, just a few weeks ago, a signature and a date were discovered carefully carved on one of the lower reliefs: "Pietro Roncati, 1851". It could be the name of the restorer and the date of the treatment he carried out.

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PROTECTION OF QUARRY STONE AND BRICK OF ARCHITECTURAL MONUMENTS AGAINST PHYSICO-CHEMICAL EFFECTS AND BIOLOGICAL DETERIORATION

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USSR

Scientifical conservation and restoration of architectural monuments are based on a principal thesis namely maximal security of monument preservation. It is a complex and long-lasting process in which experts of many professions including chemists and biologists take part.

Causes of deterioration of natural limestone (or as it is usually called white stone) of ancient buildings that has high porosity are its considerable absorption of moisture, poor atmospheric stability and high ability for soiling. As a rule architectural monuments are covered with a layer of century-old soilings that consist of dust, effrorescenses, soot, rust, resinous matters, organic pigments resulting of vegetable activity. It is not seldom when limestone details surface is covered with black hardened "become as gipsym" compositions that resulted under actions of sulphuric vapours (that are produced by coal burning) are captured by rain water and accumulate on stone surface. All this creates conditions favorable for growth of mycoflora and high kind of vegitation.

Chemical examinations help to identify materials that are originally used for building or decoration of architectural monument. Knowing composition of plasters, grounds and paints it is possible to restore a building using the same materials that were used originally. Beside this in number of cases judging by its composition it is possible to say about time of using of that or another material or of rebuilding.

Biological investigations take rather different part. It is known that architectural monuments are damaged by biodeterioration and sometimes such deterioration is rather strong. The bioterioratоrs are not uniform by their composition depending on materials of which an architectural monument is constituted. Thus wooden architecture is damaged mostly by deteriorating effects of fungi and wood worms. There are some of fungi that can under favorable condition ruin a building for one-two years. Wood worms activity is not so intensive but they do considerable harm to a building too.

On stone construction some higher plants that are pest of such monuments grow. With their roots and products of their vital activity that they excrete into masonry they produce damages more dreadful thah those due to such physico-chemical process as weathering or dust and gazes effects. Buildings that have withstood for centuries, survived sieges and wars perish under neglecting from growing on them subtle plants.

The biological examination of architectural monuments takes an end to elucidate and study specific composition of biodeterioratоrs and to suggest some recommendations on their control. It takes into consideration both its specific composition and character of materials of which

monument was made. As a rule such recomendations are individual as different kinds of deteriorating agents and materials that constitute architectural monuments call for using of different chemicals.

The biological examination is carried out before the begining of restoration to know the size of work in a good time, to have a possibility to draw up a financial calculation on producing of these works, und also to obtain chemicals needed for antiseptic treatment or radication of plants.

In 1970 we carried out a survey of Moscow and Moscow region architectural monuments being restored by the trest "Mosoblstroyrestoration". This survey showed that practically there were no one of architectural monument which was free from biodeteriorators. Most oftenly that is algae, lichens, leaf-bearing mosses, numerous species of herbs, trees and shrubs.

As a rull mosses (e.g. Polytrichum-haircap moss) and lichens (chiefly crustose as genus Parmelia) grow on outer walls of buildings, especially where moisture accumulates in soiled places or in that situated next to soil or to blind areas. Chloroccocales algae abundantly develop on outer walls of buildings, chiefly in areas with defective overflow-dikes and inside building on wet areas (walls, floor, modelling) open to light. Herbs growing on damp architectural monuments in areas next to soil promote accumulation of moiture, that is one of leading agents deteriorating building materials. Sprouting under paths and blind areas, grasses develop an enormous osmotic pressure and breach the covering. Spreading little by little they put these paths and blind areas out of commision. Specific composition of

herbaceous vegitation that deteriorates architectural monuments is rather varied and includes gramineae and dicotyledonous plants the most frequent of them are Agroupyron repens (L) Beauv, Avena fatua L, Atriplex nitens Schk, Brassica nigra L, Artemisia mulgaris L, A, absinthium L, Capsella bursa pastoris (L) Med, Achillea millefolium L, Polygonum aviculare L, Taraxacum officinale Wigg., Plantago lanceolata L., P. major L, Chelidonium majus.

Tree and shrub species grow on defective roofs, cornices, in splits and damages of masonry and also in immediate proximity of building spredding their roots into its foundation.

At all these cases roots of plants badly detereorate and destroy masonry that rather often is a great danger for building integrity and for its individual parts. As all other member of the vegetable kingdom they also excreat into environment (that is into masonry or other members) products of their vital activity: hydrocarbons, organic pigments, acids). The latters reacting with materials of masoury result in their alteration.

Architectural monuments are deteriorated by species: Betula pubescens Ehrh and B. verrucosa Ehrh, Populus alba L, Salix caprea L, Forbus aucuparia L, Fraxinus excelsior L., Ulmus laevis Pall., Acer platanoides L., Sambucus racemesa L.

Species of gymnospermous plans and of genus Quercus are not revealed by us on such monuments though old country-seats and churches are usually encirled by coniferous forests or situated in mixed woods and groves.

In biodeteriorators control it is necessary to follow the principle that plants can exist only under con-

stantly or recurrently moistening of constructions. Therefore desinfection and other extermitive measures must be preceded by the set of preventive ones that favouring to prevent moistening of architectural monument (repair and mounting of new spillways, building of blind areas, damp-proofing works and so on). In the $equel it may be of greate importance to keep a building in cleanness.

Protection of architectural monuments against biodeteriorators is rather complicated and up to date has been worked out extremly in sufficiently. In special work (1,2) there are some indication on using of formaldehyde, copper and manganese compounds for treatment of building materials surface. It is suggested to use manganese compounds for extermination of mosses. However its solutions have explicitly pronounced coloration that alterates color of building materials. The copper compounds and formaldehyde au of litte use for momumentums protection as well the first because of coloration of their solutions and formaldehyde because of his volatility.

To prevent influence of phisico-chemical and biological factors on posous materials it is necessary to creat such conditions that exclude possibility of increased humidity and pollution of stone which promote its deterioration and also facilitate the growth of biodeteriorations. To this end we suggested a set of measures which encluded: cleaning of white stone and brick, extermination of vegetation and also protection of white stone against atmospheric effects and influence of biodeteriorators by means of its hydrophobizing.

I. Cleaning of brick and white stone.

To clean white quarry stone off centuries-old deposits of soot, resinous, siliceous and other impurities without any harm to the cleaned surfaces the following three methods are suggested:

<u>Ist method</u> - washing with running water which is done by means of fire-pumps under pressure not more thah 3-4 atmosphere and of soft kapron* brushes. The water temperature must be higher than 10°C.

But pure water itself not always can remove all dirt from a cleaned surface. In such cases it is necessary to use the 2nd method.

<u>IInd method</u> - cleaning by means of detergents. The washing is performed using OP-7, OP-10 or "Lotos", "Progress", or a neutral soap. At first the surface was freed from dust by washing with water. Then one of foregoing detergents is applied on surface of stone or brick and after 5-10 minutes it is washed out with water being rubbed with kapron brushes. During this procedure environmental temperature has to be above 10°C level. If soiling is not yet sufficiently washed out the process may be repeated once more.

<u>IIIrd method</u> - only for quarry stone.

When surface of white stone details is covered with black petrefied compounds we use washing composition consisting of ammonium fluorid and surface active agents (OP-7, OP-10) and water. Ammonium fluorid concentratio is 3-5 per cent depending on soiling steadfastness.

This composition is applied (using brush) on the surface that is preliminary washed off dust with water and after 10-20 minutes washed out by wather and kap-

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artificial fibre similar to nylon.

ron brushes. It is performed under environmental temperature not less thah 10°C. If soiling is not yet sufficiently washed out the process may be repeated once more. After using this method you must thorougfully wash stone with running water (see before p. 1).

II. Extermination of vegitation.

Extermination of trees and shrubs on building is performed by means of herbicides. Especially good result are obtained using single application during of full leafliness (July) on lower part of trunks. The applied solution contains 5 per cent (by active component) of butil ester of 2,4 dichlorphenoxylacetic acid in solar oil. Death of plant is seen 2-3 week later. Since oil solutions of herbicides dammage masonry it must be sealed with polyethilene film or any other method for time of trealment. Besides oil solutions to this end we may suggest spraying of plant crowns with aqueos suspension of monuron in ratio 20g to 1 sq.m. In this case plans dye off slowly and next year control is necessary. If plant would grow they must be repeatedly treated. Beside this the solution may be applied to newly cut stubs. Such treatment may be performed at any season. As a herbicide it can be used following compounds: 10% solutions of butil ester of 2,4 dichlorphenoxylacetic acid or 2,4 trichlorphenoxylacetic acid (3) in solar oil.

For the extermination of plants that form sucker (Salix, Crataegus, Populus) around trunks circles about 30-40 cm of diameter are treated. This treatment must be done for two times.

Herbaceous vegetation is sprayed with atrazinc or symazine in dose 20-30 g/sq.m. The treatment may be

performed during whole vegetational season, but when the grass is high it must be cut before the treatment.

For the moss extermination it is good to use urea-derivates (linuron, patoran) in dose 20-30 g/sq.m^2. Dying off of mosses appearing as becoming rusty can be seen in 1-1,5 month after spraying. These compounds may be suggested for algae control keeping in mind necessary folowing hydrophobizing of masonry surface.

When white stone details are badly soiled calcium hypochlorite can be use for algae and lichens control. It both cleans white stone surface bleaching its organic substances and desinfects it. The mixture of powdery calcium hypochlorite with water is applied on stone surface prewetted by 1-2% aquous solution of sodium bicarbonate (4) and let to dry on it (during some hours depending on removableness of soiling). Then this mixture is remover and the surface is thoroughfully washed by running water until washing water has pH not higher than 8.

But in the cases when white stone is ajoint to much quantity of metal it is neeted to use not chloric lime having corrosive action but herbicides.

To prevent growth of plant along building perimeter as well as on paths and blind areas of white stone or of other building materials it is recommended to put into sand pad of blind areas (paths) some lasting-effect herbicides such as atrasin and simasine in dose 30-40 g/sq.m.

III. Protection of brick and quarry stone againt environmental effects and biodeteriorators.

After cleaning of brick or quarry stone surface and extermination of vegitation the conclusion is treatment with hydrophobic compositions (5-7).

For brick 10% solution of GKZ-94 in petroleum or white-spirit with hardening agents A M-9 or actoate of tin are used.

White stone must be hydrophobized extreamly carefully. Not every stone may be hydrophobized depending on its conditions and salt content. But not - withstanding the most effective now the following solutions are: 3-5% aquous solutions of silico organicliquories such as metylsiliconate of sodium (GKZ-10), sodium ethylsiliconate (GKZ-11) and alluminium methyl siliconate (AMSR).

In the first place wet area (next to ponds) that are susceptible to algae atacks are treated as well as blind areas of white stone around monuments.

The treatment of brich and white stone by foregoing silicon-organic composition results in forming on their surfaces of the slightest film of polymer having hydrophobic properties.

These protective coatings are unwetable, provide less degree of surface soiling, prevent possibility of growth of microflora and higher plants.

THE CONSERVATION OF LIMESTONE ANTIQUITIES IN THE STATE HERMITAGE MUSEUM

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Abstract

Authors describe methods of investigation, cleaning, conservation and restoration of carved and painted limestone objects from the State Hermitage collection and archaeological discoveries in Chersonese.

In the collection of the State Hermitage Museum there is a great number of limestone antiquities of unique value: reliefs and statuettes from Ancient Egypt and Assyria, antique stelae from Chersonese, medieval works of art from Coptic Egypt, Byzantium, India etc.

The present report summarizes the experience of the work done in the last 20 years. During this time more than a hundred various limestone works have undergone treatment. They differed in size, the kind of limestone, carving and painting technique. It is

these peculiarities of the monuments and their preservation conditions that determined the restoration method /I,2/.

The conventional system applied to the conservation of limestone works consists of the following operations:

I) preliminary examination and documentation
2) cleaning: removing soiling matter from the stone surface
3) cleaning: removing soot and soiling matter as well as renewing from the painting
4) removing watersoluble salts
5) consolidation of the stone structure
6) jointing fragments and filling up gaps.

When conserving objects with a badly decayed structure the strengthening of the stone precedes cleaning and all other operations.

Preliminary examination

The stone articles to be restored are thoroughly examined with the help of a magnifying glass or a binocular microscope under usual or ultra-violet light. In some cases special photographic records in ultraviolet or X-rays are made. By means of ultra-violet luminescence remnants of painting and traces of previous restoration are revealed. The X-rays photos show the condition of the metal frameworks applied for strengthening the joints in former times. With the

help of chemical and X-ray diffraction analyses the nature of the stonework material and of the contaminations, the qualitative composition and the quantitative content of the watersoluble salts in the stone are established.

Removing soiling matter

The soiling is removed very carefully,especially from soft limestone. Hard brushes and sponges are never applyed since they can damage the stone surface. The object is wetted with a mixture of distilled water and ethyl alcohol (volume ratio 9:I) by means of a soft hair brush. The moisture and the dirt are removed with a cotton wool swab on the tip of a wooden stick. Such swab is applied in various ways depending on the condition of the stone surface (touching, rolling on or rubbing).

If the limestone is very porous the amount of the alcohol should be increased to accelerate the evaporation of the liquid from the surface of the relief cleaned.Stains of fortuitous origin (wax, paint,etc.) are removed with similar swabs or pieces of cloth soaked in some chosen solvents or their mixtures according to the nature of the stain in question.

The cleaning of the painting on limestone

The areas with preserved painting are cleaned

from soiling by the same method, but with more care taken. A magnifying glass is used.

The cotton wool swabs are examined under a binocular microscope to see if the paint particles are not being taken off during cleaning.

Sometimes contaminations may be successfully removed without any preliminary fixation of the paint layer, as was the case with the Userhet's stele (Egypt, XV c. B.C.), where the painting surprisingly well preserved was completely concealed with the dust and revealed after cleaning.

In most cases, when removing the dirt layer, paint particles begin to crumble and flake, since the binding materials have changed during the millenniums to such a degree that they ceased to function. That's why before cleaning and in the process of it the painting is consolidated with resin solutions (mostly with polybutyl methacrylate /PBMA/ solutions in acetone, white spirit, xylene or in their mixtures, or with the polyvinyl acetate /PVA/ solution in alcohol). In this way the cleaning of the Api Stele (Egypt, XIV c. B.C.) was carried out /2/. All its surface was covered with some clay stuff of loess type. After the stele's surface had been cleaned there was revealed a multi-coloured painting with

fine detailes the presence of which could not even have been surmised before restoration. These features helped the Hermitage egyptologist N.B.Landa to exactly date the unique object from Tutanchamon's times, and not from some earlier period, as it was thought before.

Removing watersoluble salts

To remove watersoluble salts small limestone objects are soaked in warm distilled water. The water is changed periodically. The salt content is checked with silver nitrate solution. In this way salts were removed from the fragments of the Ptah's statuette (Egypt, I millennium B.C.). /2/

When extracting salts from big reliefs and sculpture objects, moist paper pulp is used. By applying this method we desalted several ancient reliefs and statuettes, among them Piramidion (Egypt, XII c.B.C.). /2/

Consolidation of the stone structure

The structure of the limestone weakened by salts needs consolidating. To conserve museum limestone objects, the application of low viscosity grade thermoplastic resin solutions or impregnation with monomers of the same resins with polymerization within the stone pores are preferable.

In the State Hermitage Museum low viscosity

grade polybutyl methacrylate (PBMA) is applied (the specific viscosity of I% solution in toluene being 0,2 - 0,5).

The impregnation technique includes various processes depending on the size and shape, porosity and degree of destruction of the stone. Complete immersion of the stone into a tank with PBMA xylene solution is used for small fragments. A more effective impregnation is achieved by a partial immersion of the object into the tank ("suction" technique). The saturation of the stone with the solution is checked by weighing.

When the object cannot be immersed into a tank because of its size or state of preservation it is placed into a chamber filled with xylene vapour, the solution being repeatedly applied to the stone by brush

The cracks and hollows are filled with resin solution by means of a syringe and a needle for intravenous injection.

Sometimes all the above impregnation techniques are applied for the treatment of one object. After treatment the quantity of the resin accumulated in the pores of the objects amounted to 5% of the weight of the stone. This proved sufficient to make the stone reinforced and to prevent further destruction.

The conservation of a number of ancient Egyptian

limestone objects by this method gave good results. When consolidating the stone Shawabty (Egypt, XV c. B.C.) in 1951, restorer E.G.Sheinina succeeded in filling the stone pores with resin up to 28-30% /3/. The statuette became reinforced and since the time of impregnation (more than 20 years) no changes have been noticed.

Jointing fragments and filling gaps

Broken or flaked fragments are glued together with PBMA of high viscosity grade (specific viscosity of 1% solution in toluene being up to 2,1) dissolved in acetone or PVA in alcohol.

The lacunae between fragments, big and deep cracks and the joint seams are filled with putty prepared from ground limestone crumbs or from some material like it (loess for example), mixed up in PVA or polyvinyl butyral solution in alcohol or PBMA in white spirit.

The treatment of limestone articles excavated in Chersonese

In 1960-61, during archaeological excavations in Chersonese, some carved architectural details and tomb stelae with pictures and inscriptions were extracted from the tower masonry (IV-III c. B.C.). They are made of local limestone and painted in a mixed

encaustic and tempera technique. There were several kinds of damages on the painting; all the objects were broken into fragments; some of them were covered with saline efflorescences, soil deposits and plant roots. The fragments contained moisture and salts (the chlorides content was 0,II - 0,4I%). Drying was accompanied by intensive disintgration of the paint layer and the limestone surface.

It was established by P.I.Kostrov that the painting on the objects could be preserved by consolidating the paint layer in a moist state. Before the restoration work began the fragments had been placed into a storage with relative humidity 88-96%.

In the field 7-I0% PBMA solution in white spirit was used for the primary consolidation of the paint layer. Most crumbly and exfoliated fragments were consolidated with 40% PBMA solution in xylene in xylene vapour (brush coating).

In the laboratory after thorough cleaning the paint layer and the crumbling areas of the limestone were additionally consolidated and covered with a protective PBMA coating.

The removal of salt was carried out with help of unbleached cellulose pulp by usual or modified methods.

In the second case the fragment was partially immersed face down on a support into a tank with distilled water. A compact layer of moist pulp I,5 - 2 cm thick was put on the surface of the object - almost down to the water level. The pulp was isolated from the water in the tank by a protective PBMA coating (4-5 cm wide) and a layer of paraffin over a cotton gause bandage (I,5 cm wide). The dry pulp was taken away and fresh pulp applied (6-IO applications). The water in the tank was changed every IO-I2 days. The whole procedure lasted from 5 to 8 months being more effective than the usual one.

Then stones were washed with distilled water and dried open. The paraffin film was taken off from the fragments while they were still wet. After release from the protective PBMA coating the paint layer required some additional consolidation and some final cleaning as well.

The greater part of the tomb stelae and architechtural details consisted of several fragments which could be jointed along the fractures. They were glued by applying 35% PBMA acetone solution with loess as filling material. Bronze dowels were put into some big fragments and cemented by the same mixture.

In this way were conserved all the excavated objects. Among them a fragment of unique value with the picture of a youth's head, stelae "Polykasta" and "Herakleios".

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PROBLÈMES DE CONSOLIDATION ET DE HYDROPHOBATION DE LA SURFACE D'UN MASSIF DE ROCHE ET DES MURS INTÉRIEURS DES CAVERNES D'UN MONUMENT DU XII^{e} SIÈCLE 'VARDZIA' (GÉORGIE)

T.V. Iakachvili

URSS

"Vardzia", un ensemble de cavernes, sculpté dans un grand massif de roche, qui se situe dans la gorge du fleuve Kourà, au sud de la Géorgie, - c'est un monument remarcable d'architecture du XII^{e} siècle.

Ce massif est constitué de roches ignées de la période tertiaire récent; dans sa coupe ou peut voir les trois couches suivantes: la couche supérieure, mesurant de 20-30 m. - une tufobrèche de grands détritus, de couleur sombre; la couche centrale, de 30-40 m - des tufs nélites et une microtufobrèche de teintes rose, claire grise et grise; et, enfin, la couche inférieure - la même tufobrèche que dans la première couche, mais à détritus moins grands.

Les cavernes sont sculptées dans la couche centrale, à des roches tufogènes, relativement molles et d'une taille facile (microtufobrèche à teinte rosâtre).

À présent l'état de conservation des monuments est assez déplorable. À l'intérieur des constructions, aussi bien qu'en dehors d'elles, un système de fissures est observé, qui favorisent les chutes des supports intermédiaires et de blocs massifs des roches de base;

cettes dernières, à leur tour, peuvent être déplacées le long de plan des fissures, à la suite d'évolution ultérieure d'érosion et sous l'éffet des secousses sismiques.

Certaines institutions de recherches s'occupent actuellement des problèmes de l'élimination des effets destructifs des fissures et de leur remplissage par différentes solutions de charge. L'ateliez spécial d'étude et de production de restauration du Ministère de la Culture de G.S.S.R, dont nous sommes représentants effectue les études des facteurs contribuant à la dégradation des monuments sous l'action de l'érosion.

L'érosion physique des roches est considérablement favorisée par l'exposition sud de la pente où sont taillées les cavernes. La direction prépondérante du vent contribue à l'humidification des mur intérieurs des cavernes par des précipitations atmosphériques. L'érosion des couches supérieure et inférieure du massif de roche (tufobrèche de grands détritus) se déroule d'une façon moins intense et ne peut avoir ancune action nefaste sur les constructions de cavernes. Au contraire, l'érosion de la couche centrale (microtufobrèche) va plus intensivement et présente une menace réelle pour le monument.

Comme nous avons dit plus haut, l'érosion et la scarification des roches sont dues à l'action de divers facteurs. Etant donné que la lutte contre les autres agents d'érosion est liée à certaines difficultés, nous avons été chargé de lutter contre les effets destructifs des précipitations atmosphériques sur les roches de pierre.

Les recherches sur les méthodes de protection des roches de pierre contre l'action des précipitations at-

mosphériques et de consolidation de la surface du massif de roche ont été effectuées en laboratiore aussi bien que dans des conditions naturelles.

Les études concernaient essentiellement des propriétés des échantillons, prélevés du massif de roche, telles comme l'absorption d'eau et la résistance; les échantillons furent traités, ou non traités, par les différentes solutions hydrophobes et fixantes.

On réalisait le travail de recherche sur les deux directions:

1) Études des méthodes de hydrophobation des roches de pierre de l'ensemble de cavernes;

2) Études des méthodes de consolidation de la surface du massif de roche.

Les examens des propriétés de l'absorption d'eau des échantillons, traités par solutions hydrophobes, ont montré qu'une solution de liquide de polyéthylhydroxyloxane à 20% (ГКЖ-94) dans le toluène a donnée les meilleurs résultats pour les roches tufogènes.

\- x -

Fig. 1 montre d'absorption d'eau (en %) des échantillons de contrôle (la courbe supérieure) et ceux traités par solution ГКЖ-94 à 20% (la courbe inférieure) en fonction du temps (en heures).

Comme l'indique la figure 1, la partie gauche de la courbe supérieure monte plus brusquement. On peut l'expliquez par le fait, qu'un échantillon à surface non-traitée des solutions hydrophobes pendant des premières 15 min. prend enviroh 80% de toute quantité d'eau absorbée. Par conséquent, même aux précipitations atmosphériques de courté durée la microtufobrèche du massif de roche absorbe une partie considérable de l'eau. Or la région où se trouve l'ensemble de caver-

nes, est de haute montagne, et généralement les précipitations de longue durée y manquent. S'il s'agit d'une surface traitée par solutions hydrophobes, la partie gauche de la courbe monte moins rapidement, ce qui temoigne d'une absorption moins intense lors des précipitations ordinaires de courte durée, en rapport de celles de longue durée.

L'examen a révélé, que dans le cas d'un traitement de la surface à plusieurs reprises par matières hydrophobes, l'absorption d'eau diminue sensiblement. Mais un traitement répété plus que trois fois produit l'effet opposé - une augmentation de l'absorption d'eau.

La baisse d'absorption d'eau, c'est-à-dire la hydrophobation de la surface, - c'est une condition sine qua non de conservation du monument, mais loin d'être suffisante. La hydrophobation des pierres érodées perd son efficacité vu de la destruction et le clivage de la surface traitée, mais affaiblie.

La consolidation de la couche superficielle érodée c'est une autre condition obligatoire de la conservation des pierres. Nous avons employé comme fixateurs les résines époxydes, l'émulsion d'acétate de polyvinyle et le silicate organo-silicié.

Les expériences ont montré que dans ce cas la meilleure solution de fixation - c'est le silicate organo-silicié, dont l'application répond aux principales exigences de la conservation des pierres, à savoir:

1) L'aspet extérieur et la couleur des pierres à consolider ne doivent pas changer;

2) La porosité et la perméabilité aux gaz des pierres consolidées doivent être proche à celles originales;

3) Le matériau consolidé doit posséder une haute résistance aux intempéries, résistance à l'eau, résistance

aux effets chimiques, aux variations de la température;

4) Le matériau traité doit acquérir la résistance aux insectes, aux plantes, aux moisissures etc.;

5) La résistance d'un matériau consolidé augmente de quelques fois;

6) La préparation d'une solution consolidante susmentionnée doit être réalisée en respectant des règles technologiques et ne doit pas être liée aux frais trop élevés, ce qui est important lors de la mise en pratique des travaux de grande envergure. Les essais de la résistance de la surface des roches de pierre ont été effectués de façon suivante. On a collé une plaque métallique sur la surface du massif de roche au moyen d'un adhésif à base de même silicate organo-silicé. Après cela, on a arraché cette plaque métallique avec adhésif de la surface de roche à l'aide d'un dispositif fait par nous spécialement à cette fin. L'adhésif, en se détachant, entrainait avec lui une partie de la surface de l'échanillon d'une certaine épaisseur. La mesure d'une tension spécifique d'arrachement nous a permis de juger du degré d'érosion ou de fixation de la couche superficielle des pierres.

Les examens ont montré, que la tension spécifique d'arrachement d'une couche superficielles du massif de roche non-traitée est 0,9 kg/cm^2.

Le traitement des échantillons par des silicates organo-silicés de divers poids spécifique nous a permis d'établir, que les meilleurs résultats de la consolidation de la surface du massif de roche ont été obtenus par l'application le silicate organo-silicé de poids spécifique de 1,24 g/cm^3; dans ce cas la résistance de la couche superficielle des roches augmente de plus de 2,5 fois (la tension spécifique d'arrachement est égale

de 2,52 kg/cm^2).

Les épreuves suivantes ont détecté, que le traitement de la surface des échantillons par le silicate organo-silicé répété deux fois est le plus efficace. Pour la première fois on prend le silicate au poids spécifique de 1,23 g/cm^3, pour la deuxième - de 1,25 g/cm^3; en l'occurrence, la résistance de la couche superficielle augmente de plus de trois fois.

Comme les essais ont montré, plus profonde est l'imprégnation de la surface du massif de roche par solution consolidante, plus est la tension spécifique d'arrachement, c'est-à-dire la résistance de cette couche. L'augmentation de la profondeur d'imprégnation dépendera entièrement des méthodes d'application du composé consolidant sur la couche superficielle, érodée et affaiblie des roches tufogènes à examiner.

Pour choisir une méthode optimale d'imprégnation par composé consolidant, nous avons éprouvé plusieurs procédés: application au moyen d'un pinceau, pulvérisation, chauffage préalable de la surface des échantillons suivi d'application de composé consolidant etc. Après avoir fait de nombreuses expériences, nous avons trouvé, à notre avis, une méthode optimale d'augmentation de la profondeur de l'imprégnation, qui consiste aux opérations suivantes: une pellicule de polyéthylène, par ces trois bords, été collée sur la surface d'un échantillon, de manière qu'elle n'adhère pas trop étroitement à la surface de la pierre. Le bord supérieur restait libre. Dans cette "poche" on versait un composé consolidant (la solution aqueuse de silicate organo-silicé de poids spécifique de 1,24 g/cm^3), après quoi on a collé à la pierre aussi le bord supérieur de la pellicule de polyéthylène. Un jeu a été fait pour permettre de remuer

la solution avec un bâton. On mettait ce bâton dans le jeu de sorte que le composé consolidant soit isolé du milieu extérieur. Cette opération a duré pendant deux jours. La profondeur d'imprégnation était égale de 5-8 mm. Ce résultat était suffisant pour conserver la surface du massif de roche, étant donné que l'épaisseur de la couche affaiblie ne dépassait pas 3-5 mm.

Il en résulte donc, que pour conserver la couche superficielle du massif de roche de l'ensemble de cavernes "Vardzia" une imprégnation des roches tufogènes par silicate organo-silicé suivie d'une hydrophobation avec la solution de liquide ГКЖ-94 à 20% est suffisante.

Cettes observations se sont trouvées complétement confirmées par les expériences, effectuées dans des conditions naturelles - sur les parties d'essai de la surface de roche et également sur les murs intérieurs de quelques cavernes.

Actuellement des travaux analogues s'effectuent dans un autre objet de la ville de cavernes, sculptée dans le massif de roche, à "Ouplistsikha", non loin de la ville Gori

Ici la roche est constitué des calcaires faibles, qui sont subis aussi à une érosion intense. L'application des composés consolidants et hydrophobes précités et les méthodes susmentionnées, d'après les données préliminaires, a également montré des résultats satisfaisants.

Il peut donc conclure, que les composés consolidants et hydrophobes choisis de même que la méthode de leur application conviennent pour les roches de pierre tufogènes aussi bien que pour les calcaires.

A SUGGESTED MODEL FOR SO_2 - WET MARBLE-AIRBORNE PARICLES ATMOSPHERIC SYSTEM

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Abstract

A model for computing the SO_4^{2-} formed by catalytic oxidation of SO_2 contained in water condensed upon marble surfaces is presented. It derives from a model (tested both in the laboratory and in the field) which describes the SO_2 transformation in haze and fog droplets.

Studies on SO_2-NH_3-liquid water system, both in the laboratory and in natural environment [1,2], show that atmospheric particles play an important role in the chemical transformation of atmospheric SO_2 in hazes and fogs.

A simple model can describe the concentration of SO_4^{2-} in the atmospheric steady-state conditions:

$$(SO_4^{2-})_{solution} = k\,(SO_2)_{air} \qquad (1)$$

The catalytic efficiency of atmospheric particles from industrial origin can be evaluated of the order of 5.10^{-4}.

The condensation of atmospheric water upon chemically active surfaces presents a system where atmospheric SO_2 can experience the same chemical reaction occurring inside atmospheric droplets.

The marble surfaces present a chemical activity in the system SO_2-liquid water, since $CaCO_3$ which goes into solution,plays in this case the same role as NH_3 in the atmosphere. The lowering of the solution pH, deriving from SO_2 intrapped into the liquid water

(scavenging by diffusion), tends to reduce the flow of SO_2 itself into the water.

The diffusion of SO_2 into the solution stops at pH≃ 2. NH_3 plays in the atmosphere the role of increasing both pH and consequently SO_2 flux from the air in the liquid water.

The transformation of SO_2 occurring inside liquid water deposited by condensation on marble surfaces, can be described quantitatively by an equation of the type (2) substituting NH_3 with $CaCO_3$:

$$(SO_4^{2-})_{solution} = K\ (NH_3)_{air}\ (SO_2)_{air}\ l \qquad (2)$$

l = liquid water content

The scavenging of atmospheric particles by condensation in form of droplets is simply described by the condensation mechanism itself. The particles acting as catalytic material are the condensation nuclei themselves. The overall coefficient K in equation (2) can be written:

$$K = \frac{\Sigma\ c\ E}{l} \qquad (3)$$

where Σ = catalytic efficiency of the particles
c = particles concentration in air
E = scavenging efficiency
l = liquid water content

In the case of water condensing upon surfaces the scavengin mechanism is actually different.

Neglecting particles which are deposited on the marble surfaces by dry deposition (turbulent diffusion)[3], the scavengin of airborne particles by the wet surfaces is mainly accomplished by the following mechanism:

1) Thermophoresis. Brownian particles move in a temperature gradient field with the velocity:

$$V_T = -\frac{1}{4}\ \frac{\lambda}{p}\ \gamma_a$$

where λ = gas thermal conductivity
p = gas pressure
γ_a = temperature gradient

since the condensation of atmospheric water upon surfaces occurs generally because the surface cools by radiation, the thermophoresis mechanism surely occurs in water condensing surfaces. The collection efficiency is simply function of the wall temperature with respect to that of the air.

2) Stefan effect. Airborne particles in the vicinity of condensing and evaporating boundaries experience a force field in which particles are repelled from evaporating surfaces and collected by condensing ones. In this case the collection efficiency (that is the particle velocity) is a function of condensing or evaporating water vapor flux. The Stefan velocity for water vapor condensing in air is:

$$V_s = \frac{D}{\rho_a} \frac{d\rho_a}{dx} \tag{5}$$

where D = mutual water-air diffusion coefficient

$\frac{d\rho_a}{dx}$ = air concentration gradient

ρ_a = air density

Therefore K can be computed only by measuring the concentration of atmospheric particles in the air, the air relative humidity, the air and wall temperatures.

In the model described by an equation analogous to (2) K can be computed as above and the alkalizer concentration can be assumed corrisponding to the saturation of $CaCO_3$ in water.

Such a model is now being tested in the laboratory.

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THE DETERIORATION AND CONSERVATION OF POROUS BUILDING MATERIALS IN MONUMENTS. A LITERATURE REVIEW. SUPPLEMENT 1975.

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Abstract

The most relevant literature published since 1969 is briefly reviewed. New developments in chemical cleaning and impregnation using silicone esters are discussed.

1. Introduction

This paper is a supplement to two previous contributions by the authors to the ICOM Committee for Conservation (45, 46). A combination of these two reviews was published by the International Centre for Conservation in 1972 (47). Since 1969 a number of articles and books have been published relevant to the subject matter. Many of these, however, compile or review certain aspects without bringing much new material (17, 53, 59).
Several international meetings have, in recent years, been partially or completely (21) devoted to the deterioration and conservation of porous building materials in monuments. The International Institute for Conservation of Historic and Artistic Works (IIC) organized a conference in 1970 in which stone was one of the two subjects (23).
The Centro per la Conservazione delle Sculture all'Aperto in Bologna, Italy has organized meetings of the Joint Committee for the Conservation of Stone of ICOM, ICOMOS andthe International Centre for Conservation (37, 38, 43).
The Joint Committee also publishes a newsletter (20).
A symposium was organized in 1972 in La Rochelle, France of which the proceedings have been published (7).
Unesco has continued to stimulate work on the actual preservation of important monuments and although most of the Unesco reports on these projects have a limited

distribution some have found their way into the open literature (53).
A special issue of Studies in Conservation stressed the importance of preliminary investigations in conservation by reporting about the work in relation to the Indonesian Borobudur temple complex (5). The problems of tropical and arid zones have received increasing attention (18, 24). Weathering of monuments and archaeological sites of mud-bricks has been the subject of some special studies (6, 52) but much remains to be done. The investigation of erosion and driving rain, requiring long term studies including the collection of data on the microclimatological conditions is usually neglected - frequently through lack of adequate funds. The much needed collaboration between those engaged in the conservation of monuments and decorative sculpture and stone and those specialized in Building Research Science could still be much improved. While a number of common research projects have been formulated (26), very little results have been reported due to lack of financial support for such investigations. It would seem that in each country a percentage of the budget allocated to monument preservation should be reserved for research aiming at better diagnosis and improved treatment. The need for experimenting on a semi-industrial scale with promising methods developed in the laboratory is clearly felt. In the absence of such facilities, progress will be slow and applications to actual monuments too incidental.

The supplementary data below is arranged according to the sections of the authors' previous 1972 publication (47) - the numbering and headings are identical.

2. Weathering by moisture and salts

The weathering of igneous and sedimentary rocks generally and as building materials remains the subject of continuing studies. Some new data relevant to the conservation of monuments is compiled by Winkler (59); more about the weathering of stone, ceramics, plaster and murals is to be found in Urbani's Problemi di Conservazione (54). Both works treat the subject matter meticulously and explain the processes responsible for the decay, clearly.

3. Moisture in porous building materials

Investigations into the thermal and hygric behaviour of certain individual monuments over a longer period have been reported. Lacy analysed the moisture balance of King's College Chapel, Cambridge and concluded that there was little chance of the relative humidity inside falling below 50^{o} C in winter because of the absorbance by the structure of moisture exhaled by summer visitors (28).

Boekwijt reported about continuous automated moisture distribution measurements in the S. Sebastiano church in Venice (3); Boekwijt and Vos about such measurements in the S. Bavo Cathedral in Haarlem, The Netherlands (4). A most interesting collection of papers has only recently become available in English translation of a Russian conference on moisture control in the masonry of historic buildings (56).

3.2.2.2. Rain penetration

Some papers read during the 1974 2nd CIB/RILEM Symposium on Moisture Problems in Buildings (10), although concerned with modern buildings, could have useful implications for monuments. Couper, e.g., discussed the conversion of wind-driven rain to surface runoff studying, e.g., the discharge patterns of rain falling onto projections and their shedding ability (12).

3.2.2.3. Vertical transport of water

Vos (57) discussed the rising of ground-water and derived a theoretical formula for the height of rise. Applying this formula to practical examples he shows that water rising from the ground into a wall cannot be expected to reach a height of more than a few meters, unless the relative humidity is very high. This would indicate that if water is found at a height of many metres it is improbable that it originated from the ground. Aspects of rising ground-water in monuments have been discussed by Vos and Tammes (58).

3.4. Thermal aspects

The measurement of surface temperatures - important, e.g., for investigating the heat transfer characteristics of walls in monuments and related condensation risks - has been facilitated by the use of infrared-to-visible image translation systems. Thermograms of frescos, painted canvases and walls in two churches in Lodi, Italy have been published (55).

3.6. Determination of moisture

There has been little reported progress in methods of determination of both relative humidity and moisture content of building materials likely to have useful applications for monument preservation. An interesting procedure to predict distributions of relative humidity, air and surface temperatures in air conditioned rooms was published by Nielsen (34). Apart from obvious applications in museum climatology this approach could be useful to predict effects when measures of conditioning monuments are considered.

4.4. Dust pollution

Observations for which - seemingly - enough evidence had been provided in the past, are now being questioned or challenged on the ground of new data. A case in point is the controversy about the role the air-pollutant sulphur dioxide plays in the crust formation on stone.
Riederer (35) believes that the conversion of sulphur dioxide to sulphur trioxide - a reaction essential for the production of sulphuric acid - is only possible at temperatures between 400 and 600°C and in the presence of catalysts. In view of this requirement the development of gypsum crusts on limestone and marble cannot be accounted for by the action of sulphuric acid, and even less so the sulphuric acid could be held responsible for the deterioration of sandstone free from calcareous inclusions. Riederer assumes then that the observed decay of stone must be due to dust (containing calcareous particles) settled on the surface of the stone and there gradually transformed to gypsum. Considering the very fine size of the calcareous grains and the presence of catalysts in the dust, the formation of gypsum is then, at least partially, related to the presence of sulphur dioxide gas. However, sulphate building bacteria are also mentioned as possible initiators of the gypsum accumulation.
Similar assumptions have been advanced by Italian geologists (30) who state that gypsum found on decaying stone is not of inorganic origin. The presence of gypsum is again ascribed to metabolism of sulphur bacteria, although the authors admit that no linear correlation had been noted between these bacteria and the amount of gypsum found in their samples.
As far as the conversion of sulphur dioxide to sulphur trioxide is concerned, in both papers literature discussing the oxidation of sulphur dioxide at room temperature, and even patents which recommend this process for the continuous production of sulphuric acid are overlooked (44). According to several investigators - in the presence of iron either as metal or as iron oxide or as iron hydroxide - sulphur dioxide is spontaneously oxidized to sulphur trioxide (42). In fact, even without any catalyst the oxidation of sulphur dioxide will occur in the atmosphere as sunlight alone is capable of generating it through photochemical reaction (44). The sulphur trioxide gas resulting thus, influences the humidity balance of the ambient air in such a way, that the temperature of the dewpoint of the system sulphuric acid-water assumes values that are above the normal temperature of the surrounding air. Which is to say that industrial air inevitably leads to the origination of sulphuric acid aerosols (25). The damage done by the sulphuric acid aerosols through gypsum formation as well as by the pres-

sure of hydration inherent in the behaviour of the soluble salts: sodium sulphate and magnesium sulphate whenever exposed to air of fluctuating humidity, have been exhaustively covered at the IIC London Conference on Museum Climatology 1967 (49) but is also discussed by Winkler (59). Moreover Thomson and White (50) have shown that urban rain dissolves limestone at least fifty times faster than unpolluted rain, which actually means that seepage of water and change of temperature (30) alone, are not capable of explaining the decay of alkaline stone. The action of acidity content of the air pollution must, therefore, be added to these physical factors in order to make the deterioration of stone comprehensible.

4.5. Deterioration by biological agents

The origin of calcium oxalates and the action of microorganisms in their creation at the surface of monuments and their role in the deterioration of stone has been investigated (36). The important role of biological agents in the deterioration of monuments in tropical zones has been stressed by the work of G. Hyvert. She described in her thesis in detail the influence on the alteration of the monuments in Cambodia (18). Later systematic research was carried out by her into the biological factors affecting the deterioration of the Indonesian Borobudur temple complex (19).

5.1.1. Remedial measures against rising ground-water

A useful review in German was published by Schelling (40). Mamillan and Boineau (31) reported a comparative investigation of various methods of combating rising damp. These authors also produced a film-in colour-comparatively illustrating the effect of various methods commercially available in France and installed by various proprietary firms. The data point to insatisfactory results for electro-osmotic methods and devices based on the Knapen-siphons approach. Experience with methods using injection fluids aiming at impermeabilisation, is encouraging but not conclusive.

5.1.1.5. Electro-osmotic drying

Electro-osmotic methods have received a great deal of attention (33). It would seem that statistically more positive results are reported from countries in Middle and Eastern Europe than elsewhere. This may be related to the preponderance of certain types of building stone, possibly containing mainly narrow pores. Some investigations in the USSR, however, strongly point to the limited feasability of electro-osmotic drying. Kurdenkov (27) measured the electro-osmotic permeability coefficient k_e for a number of stone materials in historic buildings. He judged building materials electro-osmotically active when the

index $k_e/k > 2.5$ cm/V . This criterium is less severe than that of Schaad and Haefeli (39). However, Kurdenkov's data show only one limestone with $k_e/k = 2.93$ cm/V all other values being < 2.5 cm/V. For bricks the values are between 0.09 - 0.75 cm/V. Kurdenkov's conclusions are well worth attention: '... in most cases the use of electro-osmosis for material drying is not effective. Only in exceptional cases when there are materials with h_e $(=k_e/k) > 2.5$ cm/V and in rather rare cases of materials of incomplete activity, can electro-osmosis be effective, and then only with the use of high voltages (above 100 V)'. He also concludes that passive electro-osmosis 'where galvanic electricity is used with a difference of potentials of not more than 3-5 V does not dry buildings.' Kurdenkov supposes that in cases of reported positive results, the main drying 'must be the result of some other phenomena'.

5.1.2. Remedies against condensation

Torraca (51) has proposed to protect temporarily monuments - in spring under Italian conditions - with protective plastic covering. This would allow to keep out the moist air and associated aerosols.Mild heating of the air inside the space between the plastic and the building would further diminish risks of condensation.

5.1.3. Drying by means of heating

Some attention has been paid in the literature to the adverse effects of heating monuments. The conflicting requirements of providing conditions agreeable to church-goers and suitable to the conservation of works of art have been discussed (41). It should be realized that while short periodic heating is better for panel paintings, sculpture, furniture and organs than continuous heating (48), cycles in temperature and the related relative humidity are detrimental to mural paintings, plaster and stone inside the monument. No heating at all is the only course to be recommended, the exception being the occasional heating of the structure itself to prevent condensation (32).

5.2.6. Chemical cleaning

The already known method for the treatment of stains, caused by metallic salts with chelate complexes is reported to be cheap enough for the cleaning of building exteriors (8). Characteristic for these complexes is that the chemical groups involved, catch the metal ion of the corresponding salt and keep it sequestered. The chelate complexes composed thus, are soluble in water, provided the complexes satisfy a number of requirements of which the most important is that the milieu should be either slightly acidic or alkaline. To stress the significance of this, it should be mentioned here that

chelating as a chemical reaction implies the displacement of hydrogen ions from a neutral organic molecule and that, therefore, the efficiency of the chelating agents - which are very weakly acidic - would depend on both their dissociation constants and the pH-value of the solutions concerned. Strong acid milieu would block the dissociation of the organic reagent and consequently, no chelating would occur.

The formulation of an effective stone cleaner based on chelating agents (in practice, the sodium salt of ethylenediaminetetra-acetic acid is most commonly employed) demands that the pH-value should be kept above 7 and that the chelate solution is thickened with suitable fillers to produce a paste. Materials capable of colloidal swelling mixed with finely powdered asbest, chelating agent and water, deliver one type of a cleaner known as colloidal paste. This is applied on a stone surface, left there for about two days and then peeled off. Contaminants from the stone accumulated in the colloidal film during drying are thus removed. In this manner horizontal stone surfaces can be cleaned. However, for vertical surfaces, and especially carvings, another filler in the cleaning mixture is preferred. In this case the chelating agent is blended with bentonite to form a paste which is then applied on the stone surface and again left for about two days to dry. Afterwards, the paste-layer together with the dirt that has entered it, are brushed off.

Several publications discussing systematically and critically all cleaning techniques have recently appeared (1, 11, 14, 15) and could be of great service if consulted prior to cleaning treatment. The problem of stone cleaning has also been discussed in international meetings of experts and their proceedings, containing directives how to handle these problems, have been published (23, 38).

5.3. Consolidation and protection

Papers dealing in detail with all techniques of consolidation and protection involving inorganic and organic preservatives have been repeatedly published (2, 13, 23, 29, 38, 54, 59). They present, however, no new approaches and for this reason, their content is left out of account here. Yet, as reference sources they are doubtlessly of great importance.

5.3.4. Silicone esters

In a series of articles Chvatal (8, 9) clarifies the mechanism of solidification of silicone ester-based stone preservatives and makes some recommendations about their use. The silicone esters undergo hydrolysis and polymerization which lead to the formation of silicagel. The hydrolysis liberates alcohol, whereas for the initiation

of polymerization catalysts are needed. Among these catalysts phosphoric acid precipitates silicagel quickly; hydrochloric-, sulphuric- and nitric acid precipitate it slowly; the alkali catalysts as sodium-, potassium- and ammonium hydroxide precipitate it immediately; the organic bases such as triethanolamine and morpholine precipitate silicagel with a moderate speed. Accordingly if the precipitation of the silicagel is completed while the liberated alcohol is still present, the precipitate is about to shrink and, after evaporation of the alcohol, will become brittle. On the other hand, if the liberated alcohol evaporates before the hydrolyzed silicon ester, i.e., silanol, has been cured through polymerization, a certain amount of the silanol will be carried to the evaporation front and deposited there as a crust with no merit whatsoever as stone consolidator. Moreover, an objectionable feature pertaining to the selection of catalyst would appear if for that purpose mineral acids are chosen. By reacting with carbonaceous matter omnipresent in stone, they would liberate carbon dioxide gas and thus thwart deep penetration of the consolidating fluid. This reaction would also neutralize some of the acid, i.e., exhaust to a certain degree the catalyst, and in this way protract unnecessarily the polymerization of the silanol.

Bearing all this in mind, and drawing conclusions from his own experimental work, Chvatal proposes a number of two-component stone consolidators; the one component consisting of the silicone ester, and the other one containing solvent and catalyst. The formulations that seem to be most promising are listed below.

60 parts by volume of tetramethoxysilane

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25 parts by volume of ethyl alcohol
15 parts by volume of water
0.1 per cent of triethanolamine

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50 parts by volume of methylpolysilicate

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40 parts by volume of acetone
11 parts by volume of 5 per cent formic acid

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50 parts by volume of methylpolysilicate

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40 parts by volume of acetone
11 parts by volume of water
0.2 per cent of morpholine

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After the two components are blended the mixture is at once applied on the stone, preferably in the evening, in order to retard the evaporation of solvent and water.

More significant slowing down of the evaporation is achieved by covering the treated surface with a plastic foil.

5.3.5. Silicones

The conventional procedures used to render stone materials water- repellent by employing silicones, are the subject of an article (16) which describes coherently the various aspects of these remarkable hydrophobic agents. However, the weak point of the usage of silicones, namely the failure to produce a continuous film, remains yet unchanged, i.e., it is easy using silicones to make a piece of stone water-repellent, but quite difficult to attain the same strong water-repellency on masonry that contains these very stone pieces.

This deficiency of the silicones may be avoided if instead of alkali silicone or polyhydrosiloxane, as the practice now is, an alkyl silicone ester, for example methyltriethoxysilane, is employed to provide the water-repellency. Through the use of an alkaline catalyst (potassium hydroxide) this type of silicone ester polymerizes, and solidifies in the pores of the stone. And because it possesses only 3 or 2 hydrolysable groups, the silicagel deposited after polymerization, is highly hydrophobic, whereas the film formed by it in and over the stone surface, exceeds greatly the thickness of the silicone film, and therefore, makes the water-repellency continuous, better distributed and more lasting (8). The practical formulation for the hydrophobic treatment of stone is a mixture containing: (in parts by volume) 100 methyltriethoxysilane, 70 ethyl alcohol, 15-20 water and 0.05-1.0 per cent by weight (as calculated with reference to the content of silicone ester) potassium hydroxide. At room temperature the quantity of the catalyst determines the velocity of precipitation and deposition of silicagel:

Addition of KOH in % by weight (with reference to silicone ester)	2	1	0.5	0.25	0.1	0.05
Precipitation of silicagel at 20°C in hours	20'	40'	1	1 ½	6	15

As with silicones, the hydrophobic treatment with silicone ester renders the stone equally permeable to gases.

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ROGIER VAN DER WEYDEN AND THE POLYCHROMY

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ABSTRACT. During the 15th century there was in Flanders a complex interaction between panel painting and polychromy.
Trying to illustrate an aspect of that interaction, the paintings of Van der Weyden have been examined from this point of view. Two important facts have become clear during that examination : 1) different accounts, concerning payments to Van der Weyden for having polychromed sculptures are preserved, 2) in Rogier's works we can discern some elements that have a close relation with polychromed retables. The well-known Deposition from the Prado e.g. seems to be inspired completely by a polychromed retable, while the arches occuring in several of his works remind us of similar elements in the polychromed altars.

Nowadays it is well-known there were close connections between Van der Weyden and the sculpture of his time. Several authors, among whom especially Maeterlinck (1) and Rolland (2), have already drawn the attention to that. One moment the former even supposed that Van der Weyden was first of all a sculptor (3). All authors however started their comparisons from the idea of sculpture in its traditional sense, viz. as a combination of space and volumes. Polychromy was considered as an unimportant accidental circumstance. Nowadays, on the contrary, we know that polychromy was far from insignificant and accidental during the late Middle ages, as it completely changed the character of a sculpture. Except for some cases, as sepulchral sculpture or procession statues, sculpture was exclusively frontal during that periode. Even the backside of free-standing statues was not finished off because they were to be put against a wall or a pillar. When now the element "colour" is added to the element "frontality", the result is new : sculpture becomes something like a three-dimensional painting. Therefore the aim purpose of the present concise study is to consider the relation between Van der Weyden and the sculpture of his time in the light of a new dimension, viz. the idea that the sculpture of his time was almost always polychromed. So, we do not hope to find new facts concerning contested attributions, dates or historical events, but we hope to get a deeper insight in panel painting, sculpture and their relations in the 15th century, and this by means of a significant example.

The immediate cause of Rogier's contact with the sculptors was probably his activity as a polychromer. Several arguments for those activities are found in the archives. Thus it is known that he poly-

chromed the sculpted votive monument for Mary of Evere, the wife of John III of Brabant in Brussels in 1439. For his work he received the sum of 40 riders, while the sculptor, John van Evere, only received 38 of them (4). From the comparison with other similar cases we think we can deduce that it was not so much the painter's name, but the cost of the painting materials and the detailed working procedure that were determining this price. Altough we cannot extend the matter here, it is worth noticing that polychromy was generally more expensive than sculpture. This clearly shows that polychromy cannot be considered as "less important". Several years later, in 1458, Rogier had to do the polychromy of the sepulchral monument for Johanna, duchess of Brabant and Limbourg at the Carmelite church in Brussels (5). Finally we can mention that in 1461 he had a hand in the painting of the stone statues of St. Philip and St. Elisabeth, to the order of Michel de Chaugy (6).

Formerly panel painters didn't consider polychroming sculptures as an inferior activity. On the contrary, it was one of their daily pursuits, as can be derived from a lot of old documents. No doubt the best known example in this context is the payment to Van Eyck for his polychroming six of the eight statues at the entrance of Bruges' town hall (7). It is a pity that in most of the cases, the works of art, mentioned in the documents, have disapeared now. There is only one case where we can suppose that the work itself is still conserved : it viz. appears from facts, discovered by Paul Rolland, that the first polychromy of the Annunciation, consisting of two large pillar-statues in the Mary Magdalenachurch in Tournai, can be attributed to Robert Campin (8). Besides, many years before Maeterlinck had already emphasised the close stilistical affinities between those statues and the art of Van der Weyden (9). Of course the paintings of Van der Weyden have often been a grateful subject for such stilistical comparisons. Although they can provide very interesting hypotheses, the finally leave an impression of uncertainty. To our opinion the comparisons gradually get a more definite character when the element "polychromy" is added to the element "sculpture". A well-known example therefore is Rogier's Deposition at the Prado, which makes one think irrestestibly of a polychromed altar piece. The whole aim points to that : the figures are like the sculptures that are put in a retable-case with gilded back-ground. This back-ground is not to be considered as an archaïc substitute for a landscape, but as an explicite and clear evocation of the back-wall of an retable. In this way, we have a phenomenon here that is standing midway between sculpture and panel painting. Panel painting has the advantage on sculpture that is is more expressive and natural. On the other hand there is no doubt that the contemporaries preferred the real three-dimensionality to the fictive one of panel paintings. Hardly ever has the reminiscence of polychromy been as strong as here, even in Van der Weydens paintings. In other similar works of him, like the Madonna with Patron Saints from the Städelisches Kunstinstitut at Frankfort or the Madonna from the Prado, the impression of a carved retable is less strong.

Next to that we especially want to mention another phenomenon that is in our opinion, closely related to the polychrome sculpture; we mean the typical painted frames of arches and arch-scenes, which, in a certain sense, were launched by Van der Weyden in the Netherlandish

painting. Until now those arches that occur in several panels of the Flemish Primitives have only been considered as inspired by Gothic church portals (10). On closer investigation this is not always so evident. When considering e.g. the Granada-Miraflores Altar, where Rogier is using the theme for the first time, we meet some typical characteristics : the spandrels above the arches contain wooden tracery simulated in paint. This tracery, just as the whole arch. is gilded. The arch itself mainly consists of a broad single concave frame, at which the spectator is looking frontally. It is evident that a church portal, concerning general appearance and gilding, impossibly could have been looking like this. The wooden tracery, the typical frame with carved scenes and the gilding however occur in a lot of Flemish carvec retables. The only difference with the panel paintings is that the retable decoration, probably because of chronological reasons, is usually somewhat more abundant than the painted decoration.

On the other hand it cannot be ignored that the scenes in the Granada-Miraflores Altar, (ca. 1437-38) (11) with their socles and pinacle crowning are painted in grey, so that they are manifestly imitating stone sculpture. A gilded wooden frame and stone sculpture in it are hard to conciliate, unless we suppose that we have a purely imagined composition here, a kind of ideal fusion between a retable compartment and a church portal. From this starting point, the painter can chose different directions : in paintings like Rogier's St. Johnsaltar at the Staatliche Museen in Berlin or Bouts' Infancy-altar at the Prado the arches, as well as the arch scenes, are painted in grey. We may assume that the intention there was to imitate a real church portal. In other works, like the Redemption Altar from the Prado, the Last Judgment from the Ayuntamiento in Valencia and the Presentation of the Virgin at the Escorial, all attributed to Vrancke van der Stockt, Rogier's successor as Brussel's town painter, we are facing the fact all arch scenes are coloured. The architectonic contours are gilded. In his excellent contribution about the arch motif in Netherlandish paintings, Birkmeyer interprets those polychrome groups as small paintings. According to him they cannot be simulated polychrome sculptures because of their very picturesque execution. Still according to Birkmeyer, van der Stockt would have misunderstood Rogier's original intentions, replacing his imitations of sculpture by small paintings (12). We cannot subscribe to this view. Could it not be quite the reverse, viz. that van der Stockt was accenting the polychrome aspect of Rogier's paintings, exactly because he understood them very well, as contemporary and successor of Rogier. From this point of view the picturesque aspect becomes an argument pro instead of a con : the intention of polychrome sculptures during the late Middle ages was to look as real as possible and to hide that the sculptures were only carved and painted wood. Thus when a contemporary was going to imitate such sculpture in his paintings, it is only logical that he would try to avoid all sculpturesque tactile characteristics, which he experienced as shortcomings.

We think that the above reflections can already show how unlimited the borders and how close the affinities were between painting and sculpture in the 15th century. The panel painter was polychroming, he was insprired by polychrome sculpture, while sculptors adopted

themes from panel painting, even so that we can suggest that the pane painting and polychromy of the 15th century cannot be seen seperate, but that they are two brances of art that complete and elevate each other.

NOTES :

(1) L. MAETERLINCK, Rogier Van der Weyden et les "ymagiers" de Tournai, in Mémoires Couronnés et autres Mémoires publiés par l'Académie Royale de Belgique, LX, 1900, p. 1-24.
(2) P. ROLLAND, Les primitifs Tournaisiens. Peintres et sculpteurs, Brussels-Paris 1932.
(3) L. MAETERLINCK, Rogier van der Weyden sculpteur, in La Gazette des Beaux-Arts, Paris, XXVI, 1901, p. 265.
(4) A. PINCHART, Archives des arts, sciences et lettres. Documents inédits, Ghent 1860, p. 114-115.
(5) A. PINCHART, Etude sur Jaques de Gérines, in, Bulletin des Commissions Royales d'Art det d'Archéologie, V, p. 131.
(6) L. DE LABORDE, Les Ducs de Bourgogne, Paris 1848-52, T. I, p. 482
(7) A. JANSSENS DE BISTHOVEN, Het beeldhouwwerk aan het Brugse Stadhuis, in, Gentse Bijdragen tot de Kunstgeschiedenis, I, 1944, p. 30.
(8) P. ROLLAND, Une sculpture encore existante polychromé par Robert Campin, in, Révue Belge d'Archéologie et Histoire d'Art, II, 1932, p. 331-345.
(9) L. MAETERLINCK, Rogier Van der Weyden sculpteur ..., p. 15-16.
(10) See e.g. : K.M. BIRKMEYER, The Arch Motif in Netherlandish Painting of the fifteenth Century, in, The Art Bulletin, XLIII, 1961, p. 2-3.
(11) About the problems in connection with the Granada-Miraflores-versions, wich we cannot discuss here, see : E. PANOFSKY, Early Netlandish Painting, Cambridge 1953, p. 264.
(12) K.M. BIRKMEYER, Art. cit. p. 101.

THE HIGH REREDOS OF SAINT ISIDORE'S MONASTERY AT SANTIPONCE (SEVILLA)

Sóme notes regarding the aspect of statuary

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RESUME - The main reredos of Saint Isidoro del Campo,in Sevilla,is one of the most importants works of art of Juan Martínez Montañés,sculptor who lived between the Renaissance and the Baroque epoque.One makes an introduction to the study of conservation of the sculptures of the reredos,showing some interesting details regardening the technique used by the artist in the docoration of the clothing,same of which has a raised decoration.In the skin or flesh parts of the figures, one finds two differents techniques in the same group.In the group of the very top of the reredos,there is a very dark preparatory coat and they are in a very deteriorated condition which the others are not.The mecanism of adhesion of the two coats of paint of the skin of the first group faild.The situation of the most alterated figures was the cause of their deterioration mostly due to climatic variations.

Introduction

This reredos is the creation of Juan Martínez Montañés, one of the most representative artist of the realistic spanish sculpture between the Renaissance and the Baroque epoque.
He was born in Jaen (1568) ,but from the time he was very young,he move to Sevilla.
In his work we can distinguish two differents,more or less,definite periods,The one before The "Cristo de la Clemencia",and the other period which start from 1603, the date of the execution of this,and continue until the finishing of the reredos of Santiponce.This reredos is completely his own work,as well as the carving of the principal figures.The reredos consists of three parts. The two lateral parts are covered by four raise motivs, and the central part with three sculptures.Between the architectural and ornamental decoration,corintian colums with shafts which are striped and spiral,frontals and cherubs;statues:S.Jerome,S.Isidore,Virgin(centre)In the

extreme superior part, Christ is crucified with two praying angels on the basis. On top of the two lateral parts, forming pairs, The Cardinal Virtues. In the lower and away from the body of the reredos, we find Saint John The Baptist and Saint John The Evangelist. On both sides, and inside the apse, in two niches, there are two statues in praying position of D. Alonso Pérez de Guzmán and Da. María Alonso Coronel. The statue of Saint Jerome, is the most important work of its time. In the contract he was obligued to do the entire work himself. This is an exact copy from nature, which is quite different from the more conventional statue in Llerena (Badajoz).
The polichromy of the statue, was done by Pacheco, who considered this is best example of polichrome which was imitating painting on canvas, a dull finish of polichrome at that time did not exist and he introduced this to the sevillian art, instead of the old way of brilliant effect which looked like "glaze china" accordingly to his expression.

ESTHETIC AND TECHNOLOGICAL ASPECTS

This work of Montañés, has attracted our attention due to its various problems and differents aspects which we can group toghtham as follow

A - THE ESTHETIC ASPECT

Actually the esthetic aspect of this work offers considerable variations in comparison to the original conception of the artist. The polichromy of the different pieces suffered modifications because of in latter centuries wear and restore according to the prevalent taste at the time. With this aspects in mind, we, more or less, can establish certain points as to its satate of conservation.

1 - Group which preserve its original polichromy
1.1 The four raise plaques
1.1.1. Birth of Christ
1.1.2. The adoration of the Three Wise Men, both in the lower part, and:
1.1.3. Resurrection
1.1.4. Ascention, both in the upper part.

1.2. The Saints Johns.

2- Group which conserves its original polichromy but with large or small "lagunes"

2.1. The four Cardinal Virtues
2.1.1. Justice
2.1.2. Prudence
2.1.3. Temperance
2.1.4. Fortitude

2.2. The Crucified Christ
2.3. The praying angels

In Justice,Prudence,Temperance and Fortitude ,as well as in the praying angels of the feet of the Cross ,one can see the appreciable alterations in the flesh but not on the clothing . The figure of the crucified Christ,is in a sort of niche formed by the ribs of the roof therefore it is preserved in a much better state.
There is a perturbation in the chromatism of the flesh in the first figures mentioned above in which the colour is preserved in an irregular zones which one can see by the dark coloured "secondary lagunes" of the preparatory layer of paint.

2.4. The Penitent Saint Jerome

This is the most important figure of the work.In the way that the figure is placed in the niche it shows to the spectators the right profile. It is notable that this part of the figure has suffered several important variations just the using of cloth to remove dust and dirt over the years has caused a mutation of the polichromy of which its dull finish,Pacheco polichromater,was so proud.This cleaning process over a period of years has caused a brilliants which is obvious.This of course,is the opposite intention of the artist.
Locally ,we can say that there is one detail of dull flesh still well preserved for technical studies. It is the left foot of the figure,kept from periodical cleaning.A deflection of light from this part produces an amazingly realistic efect of human skin much sougth after by Pacheco and other artists of the period.

3 - A group which suffered aditional polichromation in latter period

3.1. The Assumption of the Virgin

This work made up of the image of the Virgin surrounded by four small angels has suffered an aditional new polichromation which corresponds to the XVIII century. This intervention, one can observe in the damask of the robe and also quite extensively in the flesh.

3.2. Saint Isidore

This figure is the Patron Saint of the Monastery. It preserves the original flesh. On the contrary the clothing is a late adition painted on top of the other.

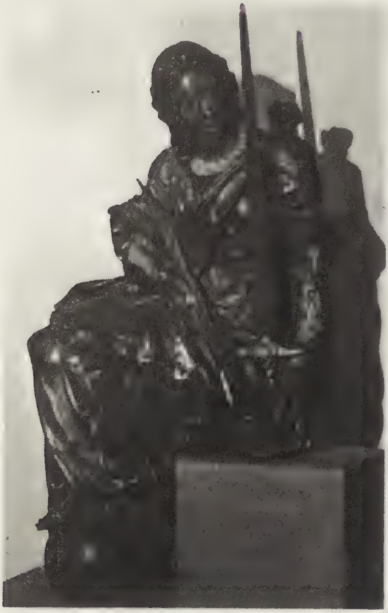
B - THE TECHNICAL ASPECT

In this work the pieces of statuary of the reredos are separated in four large raised plaques and in other smaller ones, the majority of which are small angels sostaining decorations, full figures such as Saints Johns, S. Jerome, S. Isidore and Christ crucified. Other full or entire figures, but having a background as that of The Assumption of The Virgin surrounded by four angels. Another group for example, is of plain wood, on the rear part, without any protection or polichromy, like The Justice, Prudence, Temperance and Fortitude and two praying angels. In the four Virtues, one can appreciate, the placement of large pieces of wood which form blocks and supports for smaller glued pieces in strategic places. In noting caracteristics of polichromy, we can observe the differences in the clothing of the figures. The figures of the three large raised plaques, Saint John The Baptist, Saint John The Evangelist, The four Virtues and the two praying angels, are printed motivs on the cloths. The design of the same, is made up of vegetable motivs "esgrafiados".
The edging of the capes are decorated with "grutescos" and other Renaissance themes painted on by brush. The plaque of The Three Wise Men, shows the decora-

tion of the edging of the cape of the Virgin a raised motiv utilized also by Alonso Cano and called "barbotina" or "brocade of tree heights".In this case, having as well stones incrusted , the same technique we find in another piece of the reredos. The clasp of the cape of Saint Isidore and in other sculpture which are part of the reredos of Sainte Anne also by Montañés,which is in the same Monastery.This type of raised decoration is notable for its profusion of incrusted stones.In the anterior examples,the basic preparation of the chothing in order to receive the gold leave and the top colour,must have a base of plaster and glue covered with red bole.
The clothing of Saint John The Baptist,Saint John The Evangelist,The four Virtues,the two praying angels, and The Assumption of the Virgin,are decorated with the same flat technique printed of themes of leaves and floral brocades.The edging of the capes, are ornamented with Renaissance motivs.
Plain designs without gold ornamentation,we find in the figures of Saint Jerome and The Crucified Christ.
In the skins or flesh,we find two differents techniques in the sculpture work.The difference is mainly in the composition of the coated preparation which serves as a colour base. There is a group of figures of sculptures in the lower part and in the body of the reredos in which the skin has a white preparatory coat consistig on plaster and glue and shows a good state of conservation ,noting a good adhesion of the colour coat to the base. On the contrary,the other group of figures on top of the superior part of the reredos and whose skins are over a coat of dark preparation, similar to a dark olive green,we can appreciate the important alteration in the mecanism of adhesion of the coat of the dark colour preparation and the coat of the skin colour.
The coat of oil paint which was applied to the before mentioned dark coat,is* fixed with the base of animal glue mixed with black and minium.We find that the sculptor used the same materials with sawdust added,to form a paste which was used in the rear part of same figures such as Justice,in order to remedy faults at the time sculpturing ,in which deeps holes were made in front of the figure to round out the fuller parts. This filled holes are covered with a coat of polichromy,the same as the clothig ,we deduce which correspond to the same epoque of the figure.
The coat of preparation(aquous) and coat of colour (oleose) of the skin of the group with dark preparation in the flesh,faild in their adhesion.The situation of the most alterated figures had a great deal to do with their alteration.

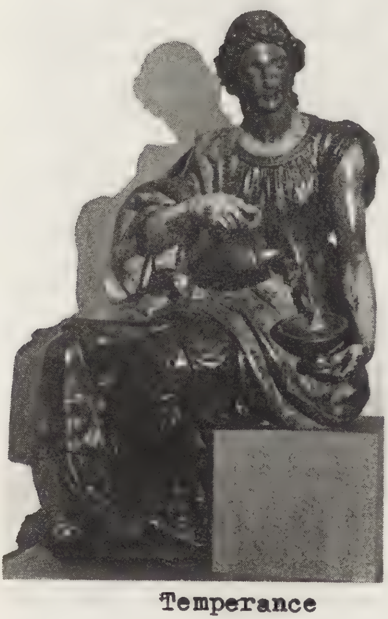
* weakly

75/6/2-6



Justice

Prudence



Temperance

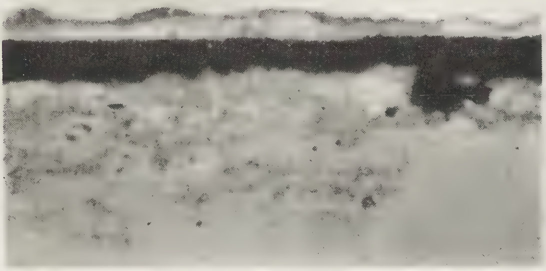
Fortitude

A detail of the figure of JUSTICE.
Noting the deterioration of the skin

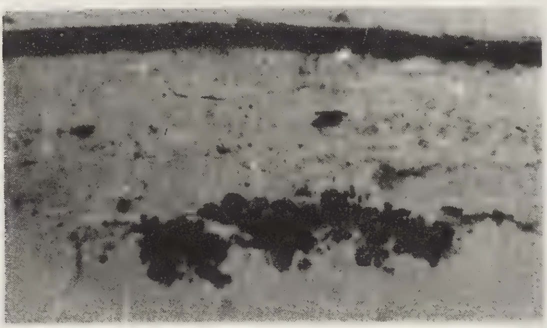
Rear part of the Justice figure. The arrow indicates the point where we have taken a sample for analization of the paste mentioned in the paper

75/6/2-8

The edging of The Temperance cape, decorated with Renaissance themes



Cross-section at the microscope
Sample corresponding to the reverse of the Temperance cape
There is no dark preparation



Cross-section at the microscope
Sample corresponding to a zone very near the skin
We can appreciate the dark preparation

ALTAR-PIECES IN AUSTRIAN BAROQUE:
WORKING ORGANIZATION, STRETCHERS AND CLIMATE PROTECTIONS - HISTORY AND ACTUAL CONSEQUENCES FOR CONSERVATION WORK

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Altar-paintings of the baroque

A special type of paintings, mostly on canvas (the interesting group on copper, tin, slate, marble or wooden panels must be escluded here), are the numerous altar-pieces or similar pictures arranged within the interior architecture of a church or chapel from the 17th to the 18th centuries. These arrangements were promoted by the ecclesiastic propaganda of the counter-reformation in alliance with the imaginative devotion of people of that time and often joined with the theatralic representation of secular authorities. Likewise the baroque altar-constructions and -sculptures our knowledge of documentary sources is much better than for medevial art. They refer not only to organization and workshop-traditions, but also let us often follow in detail the formation of the altars and the pictures belonging to with all techniques and materials used for. But the most important of all may be that we learn the purpose and intention of all these operations, which after only interpretation of analytic results or restorers observations easily can be misunderstood due to the loss of technical traditions for that kind of painting. Finally the knowledge of conservation-precautions of the painters themselves opinion with respect to climatic and environmental conditions is but a fundamental supposition for the choice of methods in nowadays conservation-work.

75/6/3-2

Function and locality

Regarding baroque paintings much more than that of earlie periods we first have to ask, whether the paintings function primarily was, because its situation from the origin and later times up to now could be totally alterated. Lots of pictures now conserved in museums or galleries original were part of a churches decoration, mostly as altar-pieces (f.e. Raffaels famous Madonna of St. Sixt at Dresden, till 1754 in S. Sisto at Piacenza). But a paintings destiny could also conduct it into reverse function. So painted Gerard Seghers, David Teniers and three other artists a great Madonna with child enthroned between flowers, arms ect. after commission of the then governor of the Netherlands, Archduke Leopold Wilhelm of Austria, for his famous collection, which after his death was united with the Emperors collections in Vienna. About 1721 this picture among others was placed in the new arranged gallery in the Viennese Court at the Stallburg, here 1730 in a miniature-view of the gallery by Storffer. Later on, perhaps after the transfer of the Stallburg-gallery to the upper Belvedere about 1780, it became altar-piece in the church of Laxenburg near Vienna, where the castle served for the summers-residence of the Emperor. Here it can be found till today.

Furthermore we normally think only of a stable function of baroque pictures. Yet within the liturgical cycle of the year many of altar-pieces were undergone to a periodical change of similar effect like the "Wandelaltäre" in Gothic times. There are several traditions with always different techniques of grounding and paintig the sometimes huge dimensions of canvas. First are mostly ungrounded hangings which were to hide the altar-piece ("Fastentücher", "Hungertücher"), whose technique of gluebound colour from the gothic period on was only little alterated in the course of the 17th century. Then we know similar painted hangings with figure scenes, which were to cover the pillars or columns of mostly greater conventual churches. A prominent example still in function for these traditions gives the parish-church (till 1787 belonging to a Benedictine convent) at Garsten in Upper-Austria. The about 8 m high Lent-hanging from Karl Reslfeld from 1696 and also the both sides with blueish camayeu-paint without any ground on a blue dyed canvas painted pillar-hangings, each of the about 6 pieces nearly 4 m high, are conserved. The picture-cycle of the one side serves for Christmas, the reverse for Easter-time. They first were made 1700 by Reslfeld together with another bibli series for the other time of the year and were repainted 177 by Johann Martin Schmidt.

Another type to change are certain altar-constructions made with a mechanism to lever several prospects or pictures (f.e. Main-Altar of the Viennese Franciscan-church, 1707 by Andraa Pozzo). Also the altar-piece itself was to be exchanged several times a year (f.e. 1678 five pictures of about 400 to 200 cm for the main-altar at the monastery of Seitenstetten, Lower Austria, or 1796/97 four similar ones by J.M.Schmidt for the parish-church at Mauthausen). The tabernacle of the altar at kilb obtained 1800 12 pictures to change from Annunciation-day to All Saints-day .

The working-organization

A number of persons normally were occupied with the origin of an altar-piece: the patron, not seldom a mediator between the sometimes lontaneous painter and the patron, the carpenter of the stretcher and the artist. A particular primer, like usual in the Netherlands at the beginning of 17th cent., seems not to have been used. The carpenter had to arrange with the constructors of the altar-elevation "because of escaping all errors with the dimensions" in making the stretcher, the mediator argued the artists quality and his preparatory sketches and also could give advice for the price, in particulăr when he arganized the written contract for the work. Whilst painting the artist could be visited by the patron or his mediator, who not seldom critizised the composition or the colours whereafter parts or the whole had to be alterated by overpainting. An example for the modalities with the carpenter and mediator give 4 pictures by Peter Strudel 1696 for the convent Klosterneuburg near Vienna, one for thus overpainting gives Martino Altomonte 1721 at Linz.

After completion the picture was let to dry and sometimes, as f.e. Joachim Sandrart did with his main-altar-piece for the Viennese Scotchs-monastery 1669 for some weeks in Nuremberg, it was exhibited for the public before beeing sent away. Therefore a provisional egg-varnish may have been adoperated, which similar procedures we also know for quick-painting-techniques.

The transport was made by means of rollers or truckles as Vasari 1550 already had marked the advantages of canvas painting, "...which is of little weight, and when rolled up is easy to transport ... Because painting on canvas has seemed easy and convenient, it has been adopted, not only for small pictures, that can be carried about, but also for altar pieces and other important compositions...". Illustrations of this first rolling methods seem to lack, but we know from baroque pictures serveral systems of stretchers, that could be taken into pieces for transport, some of them with informative inscriptions.

The erection of the picture into its altar-frame was commonly followed by conservation-precautions, of which also written sources give us precise idea. As for fixing the picture onto the frame we also know measures to give artists personal confidence of originality as Cosmas Damian Asam did with his paintings at Weltenburg, Bavaria, 1735/36 by putting up cords with his own seals.

Stretchers of baroque altar-pieces

Of about 500 paintings of the baroque restored the last ten years in our laboratories we can observe in principle 4 different types for convas-stretchers:

a) simple boards, roughly planed and fixed together with a thinner bracket nailed acrossat the top and the bottom (f.e. Bregens, St. Gallus, nave-pictures around 1760)

b) small well planed ledges, simply laminated at the corners and fixed by wooden nails, sometimes strengthened the corners by small diagonal ledges or boards nailed on (f.e. 2 altar-pieces by J.M.Schmidt 1773 at Hof-Arnsdorf or an allegory of G. Bottani from Mantua, ca1770, at the convents gallery at Lilienfeld, the latter with backside italian marks 1° (primo), 2° (secondo) ect. for putting rightly together the single pieces of the stretcher).
There exist more expensive forms too with broad ledges and horizontal as vertical reinforcements in between (f.e. St.Ann-altar at Merkersdorf, Lower Austria, by the Viennese painter Josef Greipel, about 1740, with finished inner wedges and inscription: "on this side put the picture", which nevertheless had been put onto the false reverse side).

c) two or three parts (mostly two identic shaped half ones of type b), after transport nailed together with a simple bracket backside (f.e. altar-pieces of Paul Troger at St. Andrä/Traisen or J.W.Bergl at Klein-Mariazell, which all had been brought from Viennese workshops of the artists 1739 and 1765).

d) two or three parts of the broader type b) with fine wooden locks and wedges, today know as french locks, to u There can be found types combined with protective panel work all over the pictures back too.
(f.e. altar-pieces by Michelangelo Unterberger in St. Michel, Vienna, 1751, and of the Viennese Academy professors-like Unterberger- C. Brand and V.Fischer in Karnabrunn, about 1770). (Fig. 2, 3)

A real stretchers construction with wedges at the corners we never found with original altar-paintings till the firs half of the 19th century.

For the transportable stretcher systems we yet haven't observed any second nailing of canvases when never lined till now. This argument would lead to the conclusion that great paintings, if later to be transported by rolling, were first fixed only provisionally onto the stretcher. More detailed observations if by loose nailing or by cords like usual in the Netherlands will be necessary. We have to draw further information too with the question if always the painter himself went to the place appointed for his work to put it on the stretcher, to varnish and supervise the mounting-operations. In the case of Innocenzo Turrianis altar-piece at Garsten from 1684 we know by written acts, that he never left his home at Scaria at the Como-lake and all organization was made by his countrymen, the architect C.A.Carlone and his brother Giovanni, a stucco-worker, who both were engaged in the building of the new church at Garsten, Upper-Austria.

Certain protections for the canvases edges against the rust or harm of the nails seem to miss within the Austrian painting traditions of the baroque.

Climate-protections of the 17th and 18th centuries

We are able to distinguish 5 different systems with protective function to the backside against the dampness of the walls. The proving pictures and sources mainly date from the 18 th century, but there is certainly a longer tradition too.

a) lining fo sawed or roughly planed planks which was nailed behind the picture onto the wooden frame. This was the common way, which still now can be found with best result at several main-altars with pictures of very large dimensions (f.e. Seitenstetten, Lower-Austria, 1703; Rome, Chiesa Nuova, 1594). It was further used when necessary for exposed climatic situations, like the arrangement of altarpieces into the openings of the 3 towers with side-windows for indirect lightening at the trinity-church of Stadl Paura, Upper Austria, about 1721; there it is combined with a ventilation window behind the pictures (climatic control 1975 by thermohygrographs and infrared-television-measurement). (Fig. 1) Practically the stretcher-type a) serves as climate-barrier of that kind too.

b) "planed panel-work": the more perfect but also more expensive development of the planks lining a) are well planed panels fit into a framework without any glueing. This method is called "planed panel-work" ("gehobeltes Dafferlwerk") in a letter of the late baroque painter J.M.Schmidt of Krems to the provost

of the convent at Spital/Phyrn, Upper Austria, dating 1774. There still exists a couple of his pictures, which yet not could be proved from the back. The letter says: "As for the pictures at damp places, it isn't adviseable to impregnate the back with oils, which is most dangerous to the colours that they perish. As for my knowlegde there is no better than putting the altars at a certain distance from the walls that the air could circulate behind; and the backside of the picture should be covered by a well planed panel-work as large as the stretcher. This also must not touch to the wall, because the air is for the best against putrefaction and brittleness. The most favourable would be if one could make ventilation-windows at damp places, because of the air pictures are conserved for many years."
With respect to the high expense of such a panel-work it seems only seldom have been used in reality. Both samples we found were combined with the stretcher serving as a frame for the panels, one of which was a construction of three pieces joined by wooden locks (type d: main-altar-piece of Michelangelo Unterberger 1751 at Vienna, St. Michael).

c) Filling charcoal in between a wooden cradle and the wall was another way used to fight against dampness. This was found at Rome (S. Silvestro) and is delivered for an altar-piece of Martino Altomonte 1723 at Linz.

d) Putting a second canvas onto the stretcher beyond the painted canvas (without any lining) might have been taken for a moisture-barrier too.
We found it with and without grounding of the second canvas at 3 altar-pieces in Lower-Austria (from P. Troger 1739 at St.Andrä/Traisen and from V.Fischer and C.Brand about 1770 at Karnabrunn).

e) Oil-impregnation of the painting-canvas itself was perhaps the widest used method from early times to the 19th century and unfortunately till nowadays. It just is mentioned 1630 by De Mayerne but was later on refused by experienced painters like the above cited J.M.Schmidt (1728-1801) of Krems because of its drawbacks. But he only thought for the disadvantages to the deep and dark subtle glazes of his rembrandtesque painting-technique, whilst we now pay better attention to the ruin of the canvas by the fatty acids of the oils.
Written recipes of this kind come from the painter-restorer Burgau in Linz 1739/40, who restored the pictures of the conventual church at St. Florian, Upper-Austria, at that time. He calls "Tingierung"

for an impregnation of the backside made of turpentine, poppyseed and spike-oil. To draw "dampness and moisture" out of the pictures he brushed both sides with hot turpentine-oil and after waiting 2 hours "sprinkled" them with fire-glow. After drying they had to be impregnated with the "Tingierung" and repeated till "Colour comes like fresh". One day after the paintings were varnished with "English varnish". This dangerous fire-method we know later from Dossie's Handmaid to the Arts (London 1758) and Secco Suardo's Il Restauratore dei dipinti (Milano 1866).

Consequences for conservation of altar-pieces today

Above all we try to documentate all types of original stretchers and backside-protections, proving their authenticity, date, later alterations and last but not least their effectiveness in correlation with the environmental climate-situation.

There are cases where the oil-impregnation apparently had saved the picture from total putrefaction because of groundmoisture raising behind the altar up to the vaults (pictures by J.W.Bergl about 1760 at Klein-Mariazell, Lower Austria, backside irored-oil-impregnation from 1887). On the other hand similar procedures had caused hard and extensive crackles of colour and ground and had made the canvas brittle and fragile.

As for the lining of such paintings with predominantly large dimensions and bad climate-conditions the conservation has to respect this situation. Therefor after swelling, flattening and regenerating the proper structure of canvas, ground and colour by the aid of solvents and aquaeous carboxymethylcellulose under warm pressure we still adhere in Vienna to the wax-resin-liming (using now Lascaux-Klebewachs 443-95) with best results on glassfibre-weavem. To avoid any risks at conditions we can't controll or influence after the picture has been sent back to the church (winter-climate normally 5° C and 80 - 90 % r.h.) we principly refuse other synthetics for the lining of altar-pieces, when not proved at all circumstances for a long time.

To serve as moisture-barriers we leave the conserved systems a) and b) in its place and function whenever possible. After relining and putting to a new stretcher in all other cases we took earlier ("Styropor") but are using now for better handling and to avoid attack of insects strong isolating paper with asphalt-impregnation or limed with an aluminium-foil.

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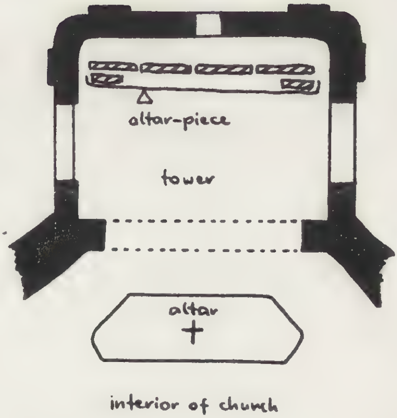
Abstract

Baroque altar-pieces from churches require special considerations and precautions when restored today. Most important to know for actual conservation-work are the manipulations made therefore just from the origin. We can follow by literary sources and the pictures come down to us the arguments for certain operations, some of which up to now are still well apted for conservation purpose. Samples of the 18th century are given for 4 different kinds of stretchers, only the transportable systems of which with certain wedges, then about 5 different moisture-barriers and the way of organizing the execution of such a painting. Finally consequences for today conservation work are shown as drawn by the laboratories of the Bundesdenkmalamt in Vienna.

Fig. 1

Stadl Paura, Upper-Austria, Trinitychurch

Scheme of altar-pieces, ca. 1720, in an open space within the tower showing original climate-protection at backside of wooden boards



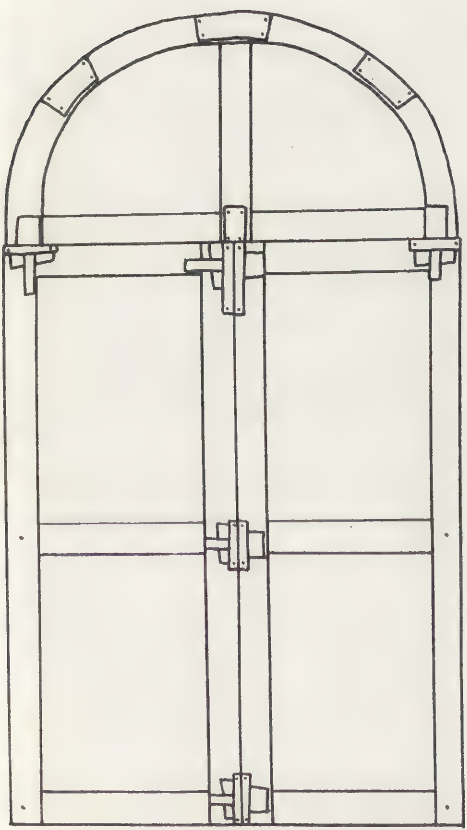
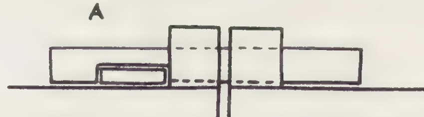


Fig. 2

Karnabrunn, Lower-Astria, altarpiece ca. 1770
original transportable stretcher with A) wooden locks and wedges and B) a second unprimed canvas put beneath the painted one to serve as climate protection

A



B

BAROQUE ALTAR-FURNITURE AND SCULPTURE IN AUSTRIA: TECHNIQUE, POLYCHROMY AND CONSERVATION

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Baroque altar-furniture in Austria

In the whole country we may estimate about 20 000 altar-furnitures and pulpits from 1600 to 1800 still conserved. This may be about 80 - 90 percent of the whole number existing at the end of 18th century, whereas in contrary lower than 5 % of medevial altars are to be found, that originally had been.
Within the known traditions of a two hundred years the earlier period of beginning baroque style is but small preserved, because of the loss of the greatest part during the renovations in the late baroque style of 18th century which predominates the artistic interior whole over the country till nowadays. About 10 % of these baroque altar-furnitures may be made of marble or stucco-work. The rest was made of wood with often fascinating polychromies the development of which could also be cleared.
There was a certain rhythm inner these stylistic changes that also led to the re-using of precurrent works within a new-built architectural composition. Serving as illustration we look for the main-Altar of the conventual-church at Kremsmünster, Upper-Austria. The medevial one had been substituted in 1533 by a renaissance one. In 1618 an new oak-wood construction about 10 m high was erected, into which some sculputres of the elder precursor were integrated. Finally the now existing marble-architecture was executed in 1712. Renewing therefore was done every hundred years.

Not seldom altar-furnitures had been wholly of in part transmitted to another place, after the polychromy had been renewed. Similar traditional consciousness show the several cases where whole gothic "Flügelaltäre" had been enclosed in a baroque altar-building, which mainly was done at the beginning of the 17th century. They had been sometimes overpainted, but often following quite modern ideas by taking "the same colours as they had been" in medevial polychromy (Zell/Pettenfirst, Upper Austria, 1668).

Organization of works and workers

By means of different literary sources we fortunately kno a lot of the organization of those altar-constructions an their embellishment. There are most informative the contracts between patron and all craftsmen, bills, inscripti that can be found at the back of altars or figures, sever notes which indicate exactly the materials to be used for remarks or critics in cases of failing or quarrels about damages and further more. Some contracts carefully fixed detailed conditions and controll-demands for execution a the best. In Zell/Pettenfirst 1667/68 the sculptor and th carpenter had to controll each others work, they both had been supervised by the parish of Ried and after the work had been finished all damages due to failures or damages at transport or collocation had to be repaired without an payment sometimes until the third time. We know at Gröbmi Styria, similar reparation-claims even 30 years after the contract requested from the son of the executing sculptor

The invention of an altar-furniture may be due sometimes an architect (commonly for marble-work), in most other cases to a sculptor, but also painters or carpenters inve tions are known including preserved models and designs. The drawn models are called "Visierung" and often showed the contracted polychromy, so a yellow colour for the par to be gilded. Sometimes marble-designs had been given wit comment of the singular types to be used for. Another ti we see, that the patron could select between a different number of polychromies according to different prices like in 1700 the painter Adam Pürckmann of Salzburg offered at Ebenau: "gilding ... 320 fl., if not gilded but a blue ground 290 fl., if marbles-imitation 230 fl., if sculptur and decorations like alabaster 200 fl.". Another case, th new altar at Brunnenthal near Schärding, Upper-Austria, show in 1663 that the polychromy first contracted (ebonis black with gilded decorations) was afterwards wanted to b changed (after advice of the districts jugde, who thought that peasants would be of bad devoteness with an polychro unusual to them). But nevertheless the black-golden-polychromy was executed by the craftsmen, who had prior been approved by a commission of other colleagues, who had bee called by the patron to critizize their work.

As to the execution of polychromy we are well informed about the division of labour between all adoperating craftsmen (Zell/Pettenfirst 1667-69 and others). The carpenter and the sculptor here were forced to erect already white primed their whole woodwork. Consequently following the contracts the painter had after to smooth this priming and to bring up his gilding and polychromy whereas only the sculptures he was allowed to paint at home at his workshop and mount them after to their place. Painters price was almost always the highest amongst all, because of his precious material as wanted one time much more, the other time little less expensive than his practice working.

Amongst all craftsmen-artists we have now to ask for the painters function more in detail with purpose of better understanding performance and results of polychromies. The main questions are who, when and where the polychromy had been executed coming to delicate problems of artistic models and technical traditions.

Painter and polychromy

Normally painting and gilding were performed immediately after the woodwork had been finished (cf. inscriptions at the backside of the main-altar at Imbach, Lower-Austria: carpenter June 17th 1671, painter September 17th 1671). On the other hand often had to be waited for a few years to some decades on behalf to collect money enough for the expensive gilding and so on (cf. main-altar at Gurk, Carinthia: woodwork 1626-36, polychromy 1654). Periodical Overpainting followed often renovations of the whole interior. Figures normally had been repainted more times than the altar-buildings. About 10 % of all preserved altar-furnitures show their unaltered or only revarnished original surface till today. By inscriptions we are sometimes well informed about these renovations (cf. Pietà of J.P.Schwanthaler at the parish of Ried, Upper-Austria: signed 1784, partly overpainted 1845, 1899, 1946 and at least well restored 1973/4).

The place where a polychromy had been executed could change from time to time after the painters or the patrons preferations. It could be the often lontaneous painters workshop when neighboured to the sculptor with disadvantage of transport-risks afterwards. The figures and ornaments always seem to have been polychromed separately and when finished fixed to the corpus by means of great iron nails without respect to the polychromed surface. Some documents give information too on execution of altar-polychromies at monastery-churches done by order-men at their convents house.

About the profession of the polychromy-workers they comm had been members of the painters-guild. These painted al kind of work from churchroofs to portals-coulouring, pol chromies of figures and sometimes paiting of altar-piece too. Black ebonised work had been due to the carpenter w as the painter only finished with priming and gilding. T priming of carpenter and sculptor has been mentioned abo But the sculptor could even do the polychromy at a whole like 1769 at Köstendorf, Salzburg, the sculptor J.B.Hage wanted himself polish-whiting because of he was apprehen of his figures beeing "misprimed" ("vergründet") by a fo ing painter. Another reason for painting sculptors or sculptoring painters was the economical and artistical competition caused by the tiring living-conditions of her craftmenship.

Finally the problem of influence to polychromy by easel-painting of the time would be of high interest. We think f.e. to the Rubens' friend Jörg Petel in Bavaria, his Rubenslike flesh-polychromies and similar phenomons in contemporean sculptors in Middle-Europe. As for the marble-imitations furthermore comparisons may be drawn between architectural compositions of inner-space or stage-sceneries and altar-polychromies. Illustrating thi we may recall the favour of the beginning 18th century for columns and other parts looking like Lapislazuli, which had been imitated by putting brass-veins into blue stucco-work or only oil-bound goldleaf-strikes within a blueish marble-painting (cf. Filippo Juvarras drawing of a theatralic-scene 1711, Vienna, Nat.Libr. to an altar-polychromy "in the manner of Lapislazuli" 1720 by Karl Greiner at the Viennese Mariahilf-church).

Materials and techniques of polychromy

We cannot refer here to all common colours, mediums, met working-operations. But we will like to show the variet within the believed traditions and to bring back to memo some forgotten techniques of coulouring, gilding and var ing.

By several material-records, dating from 1660-1795, we l ned the used materials and their trading places (f.e. Vi for the support of Hungaria, Slovakia ecc., Augsburg and Nuremberg for gold and silver). For priming served ther for glue and chalk of sometimes two qualities (Bolognes and Cologne-), pumice-stone and pewter-grass was took fo smoothing. Cheap Venetian white lead had been used for m ble-painting, more expensive sorts presumable for figure polychromy. 1746 Prussian-blue had been bought at Vienna for altar-furnitures now in Slovakia. Further yellow och English red, zinnabar, smalt, "umbraun" (Kassel-earth), safran. Verdigris has been purchased 1674 and 1795 for altars in Sàlzburg and Upper-Austria.

Black-polychromy of altar-furniture was 1674 made by "oil-colours", which afterwards had been varnished by darkred "Florentine-lac". At the case of black-ebonised polychromy the use of bees-wax for polishing and surface-protection can be taken from notations that wax had been given to a carpenter (St. Lambrecht 1641) and can be proved too by polishing of untouched ebonised work at todays restorations.

On metals use we know of 6 different products serving for the polychromy of a single work (Zell/Pettenfirst, Upper-Austria, 1666). The best and most expensive gold-leafes came from Augsburg, minor qualities were taken from Nuremberg and Regensburg, then even "Zwischgold" like known from gothic traditions are noted and finally silver from Nuremberg. In 1674 bole, egg-white and minor spirit is mentioned with gilding. Then always a lot of brushes was paid for and even a sheeps-skin for bridled horses when St. Martins or St. Georges figures had to be made.

Mainly in 17th century the black-peinting with final varnish of "Florentine-lac" had been called "browned black" (Schwarz prauniert: Zell/Pettenfirst 1668). At the same time a similar widely used gilding called "browned gilding" (vergult prauniert) could be found at many contracts and thereafter at figures and altar-columns too, dating from about 1620 to 1760. They imitate bronze-like surface and had partly been glazed when used to design details of face ecc. at wholly gilded statues (cf. Stams 1618). This "browned gilding" could also be combined with the normal polished bole-gilding, which was to be found f.e. with the bole-gilded seam of a "browned-gilded" garment of a figure dating about 1637 (from Hans Spindler, Kirchberg near Kremsmünster, Upper-Austria).

Two rococo figure-groups by J.P.Schwanthaler, dating 1784/1785 at the parish-church Ried, Upper-Austria, showed a fascinating well conserved polished bole-gilding at the outer garment with precious "Vermeil"-strikes of a yellow gum-lac mixture applied to the touches of the single gold-leafes at the bottom of drapery-folds. This "Vermeil"-technique exactely has been described by Watin (first german edition 1779) as 16th operation of gilders-work.

As for the technology of flesh-polychromies mainly could be found figures which showed two, sometimes three layers of different colours, thickness and structure and with or without desings of browes or eyes even at the layer beneath the final touch. This is illustrated by Fig. 1.

75/6/4-6

Problems of conservation and restoration

The main problem for conservation we everywhere found misunderstanding of the sensibility of polychromies but also false ambitions to restore the believed "original state" without proper examination, learned specialists and small money and time too. We found figures with more than 15 layers belonging to overpainting. The double-layers of carnations were the most difficult work, becau of the upper adhered often better to the overpaints than to its underground. The complicate surface of areas like hairs or beard are due to take many weeks work for delivering a single figure from its overpaintings.. But thereafter strong protective coatings will be necessary for future conservation. We used Paraloid also on original gilding and tried Calaton-Nylon for glue-bound par Further experiences are necessary to ensure the best way

Another main-problem consists in wood-conservation. Actu worms activities was found nearly at 15 % of all works e mined. Further harm is done by spreading of church-heat the most dangerous of all coming from heated air circula system. Exhibition-damages also call for better understanding of the complexe equilibrium of climate, environ ment and wooden polychromed figures.

The consequences to be drawn should consist above all in concentration of all forces to conservation merely, examination of damages and technology and basic documentation. The experiences drawn with our work since 1970 had been discussed in 1973 amongst the last meeting of about 120 restores in Vienna. The given documentation (Restauratorenblätter 1974) and further informations wil be submitted to all competent offices both statal and ecclesiastic ones and naturally to all private restorers working on this field.

Finally we always try to propagate the conservation of overpaintings if the actual possibilities don't guarantee a precise and subtle work without new losses of reductions of the original polychromy. This directions which include a prior examination just have turned out well several times, when not only original polychromy but also bad spent money had been saved and chance given to future help.

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See also the contributions to the relining-group (on baroque altar-pieces) and to the varnish-group (problems of varnish).

Abstract

Examination and restoration of a great number of polychrome altar-sculptures(ca. 260) and altar-furnitures (ca. 130) from the 17th and 18th centuries coming from several workshops mainly in Upper-Austria showed not only the close technical traditions and their development over two centuries but offered many questions to original technology and conservation traditions too, that partly could be answered. Discussion is given about the usual collaboration between patron, sculptor, painter, carpenter or other craftsmen to establish such a complexe work as a polychromed altar with his integrated sculptures and paintings, furthermore about the materials and techniques used, about price, time and trading of the materials needed for until arguments and methods of reparation or alterations within baroque time.

Illustrations:

1) Carnations composed of two layers at polychromes of figures by the Schwanthaler-families sculptors and their predecessors (after micro-sections: 1 wood, 2 priming)

a) H.Spindler ca.1637 b) M. Zürn, 1649 c) Thomas Schwanthaler, 1669

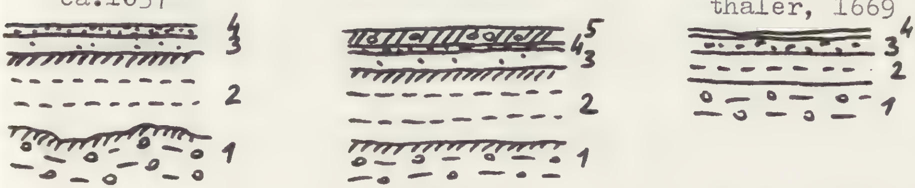

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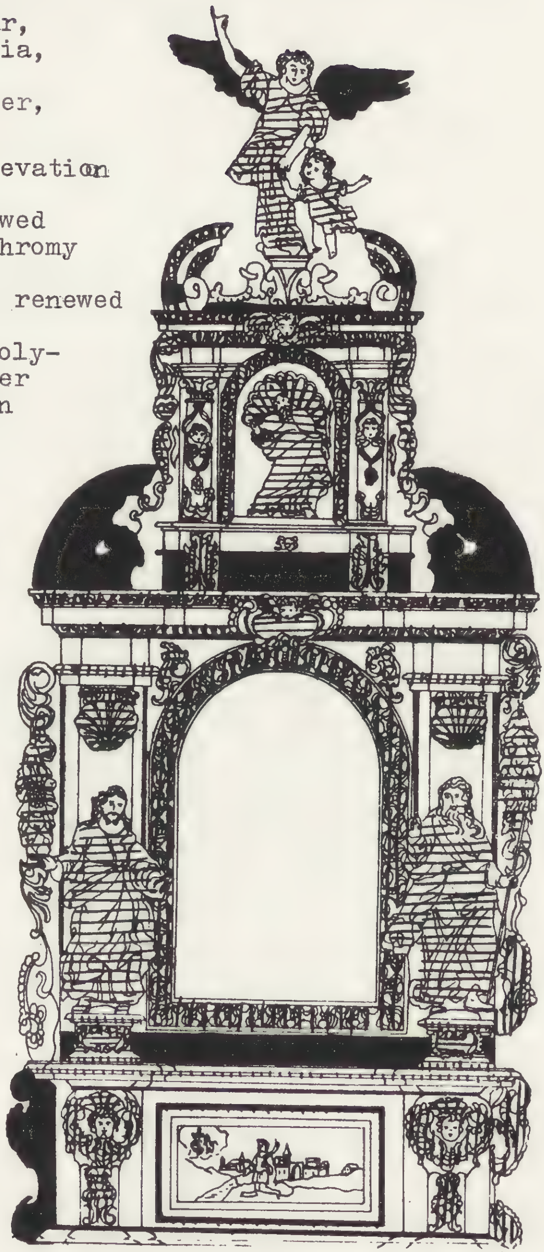
Fig. 2)
St. Florians-altar,
Ried, Upper-Austria,
Parish church
Thomas Schwanthaler,
sculptor, 1669

photogrammetric elevation
state 1974:
black: tatal renewed
horizontal: polychromy
of 1842
vertical: gilding renewed
1973/4
white: original poly-
chromy after
restoration
1972-1974



1 M

METHOD OF EXCAVATION CONSERVATION AND STORING OF THE POLYCHROME SCULPTURE ON THE CLAY BASE

V.A. Lunev and H. Musnitdinnodjaev

USSR

In the year 1959, on the south of Uzbekistan in the Surkhan Darya region near the present-day city Denau, the Country palace was discovered by archeologists of the Hamza Institute of Art, it has been named after the site of Khalchayan. A long time ago the palace had been situated near a large ancient city, the Country palace survived and its ruins still can be seen separately standing among the cotton fields of the Khalinin kolkhoz. The modest proportions palace building dates back with the I-st century B.C., the epoch of the Great Kushan. It was decorated with sculptural relief, paintings and the polychrome sculpture.

For the sake of investigations the technique and the way of executing the ancient sculpture and its fixation in our conditions, we used the method, worked out by us, which appeared to be the most acceptable one.

After archeological discovery the found sculptural fragments have been made cleaning and fixing with solution polybutyl methacrylate in xylene (PBMA). In the process of cleaning the separately lying fragments and piled up on each other ones have been divided and got

rid of sticking to them clay, dried up on the sun.

Then, on the restored material the solution of PBMA was applied (1:7 or 1:10 till 10-15 times during 2-3 days), the fragment has been covered with a firm crust of polymer 1-1,5 sm. sick.

After the final drying the fragment has been covere over with aluminium foil upon which the frame made fro wire of diameter 3-6 mm has been laid, then the plaste was put on.

A sheet of veneer or a plank were put under the sculpture in the plaster block and when turned it up, the further cleaning was carrying on. Having dried thi side on the sun then fixed it again with solution PBMA

If the piece was big or badly cracked, the plaster was repeated again wholly enclosed the fragment into the plaster cuirass. The plaster block protected the archeological material during the transportation in expedition cars.

The finishing conservation and matching of separate fragments were carried on in the laboratory.

Till 1964, we used in our laboratory methods of fixation of polychrome clay sculpture which were practiced by the Hermitage Museum and by other restoration laboratories in the Soviet Union.

Beginning of this year we used both methods, the previous and the new one, worked out by scientific workers of our laboratory under the guidance of the candidate of chemistry sciences E.F.Fedorovich (Author's certificate N° 180986).

The nature of this method is as follows: the fixati of sculptural fragments is carried out with solutions of monomer but not of polymeres (butyl ester of methacrylic acid). Technical butyl methacrylate contains

hydroquinon. For receiving clear colourless monomer, it washes well with 1% of alkalies and after with water. Washing is carried on in special funnel furnished with tap, this makes washing more simple as it is seen the formation of two layers, the upper one of monomer and lower of water layer with alkalies and hydroquinon.

Washing repeated 2-3 times till the brown alkalies layer will be colourless. Absence of alkalies in monomer can be defined by dropping with phenolphthalein if the sample do not tinged pink colour that means the monomer is clear.

Into clear, from hydroquinon and alkalies, monomer carry for drying up anhydrous sodium sulphide in quantity of 100 gram on litre of monomer and mixture is left on 12-16 hours.

To check up the dryness of monomer, to its separate test is added a small quantity of xylene or white spirit. The absence of white turbid shows the readiness of monomer to the work.

In mixture from 9 parts (of volum) of monomer butyl methacrylate and one part of xylene or white spirit are added 2% (of weight) of benzoyl peroxide- that means 20 gram on 983 ml. of mixture. Liquid is shaked till the full dissolving of benzoyl peroxide. Then the sculptural fragments are soaked with this mixture.

If the fragment is a large size (40x30x80) it must be soaked in the plaster block covered with aluminium foil and after dried in the special drier. The polymerisation of monomer is carried on with keeping the temperature regime. At first the temperature is raised till 70 degrees C., and during 2-3 hours increased till 110 degrees and on this level is supported 2-3 hours.

When the polymerisation is finished the fragment mus be cooled to the room temperature. After it is taken out from the special drier and it has to put into the fume cupboard for removing the smell of polymere.

The main work of sculptor-restorer begins after the fixation of fragments, their cleaning, matching and pasting into the whole composition or the separate elements and images.

The parts of sculpture were pasted with glue of beads resin (PBMA) which are reversed, do not enter into reaction with paints.

In separate cases for the sake of more close reunion of fragments into glue is added some loess dust carefully sifted through the capronic sieve.

In the laboratory all parts of sculpture were collected and pasted according to their cipher in the fields conditions, that means, on the lable is written the cipher of square, circl and if the fragment appeared to be finished and is exact part of sculpture then the ordinal number has been given to it.

All this data were marked on the archeological map with sketching of every piece of sculpture.

After completing of the whole cycle of work on conservation and restoration, the masterpieces of art culture have been handed to the State Museum of Arts of Uzbek SSR.

RESTAURATION D'UN RETABLE DE TALLINE DE BERNDT NOTKE

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Le retable de l'église de Saint Esprit est de date plus récente que son architecture et, d'après certaines documentes, est considerée comme oeuvre de l'atelier de Bernt Notke. De toute évidence, il fut instalé dans l'église en 1483, à en juger de l'inscription dans sa partie supérieure. Le retable étaite remis à neuf deux fois, en 1625 et en 1815, et c'étaient avant tout des sculptures couvertes de couches des repeints à la détrempe et à l'huile, qui en ont fait l'objet. Avant que notre groupe ait procédé à ce travail, on avait tenté de dégager la polychromie originale, ce qui avait provoqué des lacunes considérables de la couche picturale et de la préparation sur le visage de donateur (?) - un personnage s'agenouillé dans la partie gauche de la caisse centrale.

De nombreuses petites lacunes de la préparation et même du bois sculpté peuvent être expliquées par les déplacements fréquents du retable au cours du XX^e siècle et par le travail des renouvelateurs. Malheureusement, lors du traitement on tirait les sculptures de la caisse centrale et du tabernacle sans ménagement nécessaire. Le traitement était limité à un coloriage des sculptures sur la couche picturale et le vernis anciens. Les parties manquantes, apparues sur les sculptures et le décor architectural, sont dues également à un nettoyage de chaque jour du retable de la poussière, suivi peut-être d'une légère humidification.

Des le début du travail on a décidé de restaurer les sculptures du retable sans le démonter, en traitant graduellement une figure après l'autre. Le traitement

consistait à la fixation de la préparation et de la couche picturale par dispersions aqueuses à base d'acétate de vinyle ainsi qu'au dégagement de la polychromie originale au moyen des solvants organiques employés dans la conservation de la peinture à la détrempe et des pâtes préparées spécialement.

Après avoir fixé au préalable les préparations des sculptures in situ, dans le retable, on les a tiré, on les a fixé encore une fois et ensuite on les a transporté en laboratoire pour le traitement de conservation.

A partir de petites demi-figures, on a passé successivement aux groupes de deux ou trois apôtres, puis aux figures des volets du retable. Au cours de restauration la documentation se trouve accumulée. En raison d'un certain intérêt historico-artistique des repeints de 1625, les notes ont été faites d'une manière aussi détaillée que possible.

Description générale du retable. Actuellement le retable de Talline n'a ni une predelle peinte ni celle sculptée: la caisse centrale s'appuie sur un support massif, composé de barres de chêne ajustées étroitement l'une à l'autre. L'hauteur du retable, du piédestal jusqu'au haut, où se trouve une scène "Couronnement de la Vierge", est égale de 3,50 m.

La caisse centrale est flanquée de caisses-volets latérales acrochées au moyen des boucles de fer forgées. La largeur du retable dans l'état ouvert mesure de 3,60 m. Le retable aux volets ouverts ne présente que des sculptures. Dans la caisse centrale nous voyons la scène "Descente de Saint Esprit". Jadis, dans sa partie supérieure, au-dessus d'apôtres, se trouvait l'image de "Saint Esprit", perdue à présent, comme la plupart de petites figurines des prophètes aux rouleaux, se situées au niveau de fenêtres décoratives. Seulement deux de ces prophètes se sont conservés: Job et Tobie.

Dans la partie supérieure de la caisse centrale il y a un sarment avec une sculpture du Christ, tandis que sur le fond des parties latérales d'encadrement se détachent les petites sculptures de Sainte Catherine d'Alexandrie à l'épée et de Sainte Dorothée (?) portant une couronne de roses, mais sans attributs, perdus autrefois.

Dans les caisses latérales nous voyons les demi-figures et figures en pied, qui se situent comme suite: le volet gauche, en haut: Saint Olaph et Sainte Anne ( ); le socle: une Sainte à un modèle de

l'église à la main (Sainte Elisabeth?), Saint Jean-Précurseur; le volet droit, en haut: Sainte Elisabeth et Saint Victor; le socle: Saint Antoine et Sainte Barbe. Outre cettes sculptures, les caisses latérales ont été ornées de petites figurines des prophètes, qui se trouvaient sur les demi-colonnes devant les parois divisantes; elles sont analogues aux images de la caisse centrale.

Le retable est couronné d'un groupe sculptural "Couronnement de la Vierge", où Dieu-père, Dieu-fils et Marie agenouillée sont représentés sur un trône commun.

Sculpture. Toutes les sculptures du retable sont faites des morceaux entiers de chêne, à l'exception de quelques éléments des figures; par exemple, les mains ou les attributs sont sculptés séparément et sont fixés vers le principal volume au moyen des pivots de bois et de la colle animale. Parfois, elles sont fixées par des clous de fer (par exemple, la main d'apôtre Paul, l'aile d'un des anges à bouclier), mais ce ne sont que des exceptions. On creusait les sculptures par des burins demi-circulaires, bien affilés, on bouchait de petits noeuds du bois et des fissures à l'aide de petits morceaux de chêne et de la colle additionnée de craie. Bien que les bases de certaines sculptures ne soient pas sciées, mais taillées, on peut voir de nombreuses traces des pointes de fer, qui temoignent de l'usage traditionnel d'une machine-outil de sculpture. Les revers des sculptures sont traités d'une manière assez négligeante en comptant de ce qu'ils ne seront pas visible au spectateur. Le travail est parfaitement précise, au point que les sculptures adhérent étroitement à la surface du mur; pour cet effet, lors du montage des sculptures, on taillaient les oeuvres déjà couvertes de polychomie.

Les sculptures rondes isolées sont exécutées des morceaux de bois entiers, sauf une figure de donateur agenouillé (?) faite d'un seul morceau, en ébauche, creusée du côté du dos, puis recouverte d'une planche de chêne et achevée.

Les sculptures sont bien conservées. Les visages et la plupart des bras des statues d'autel ne sont pas endommagés, les parties cassées ne sont pas nombreuses. Presque toutes les sculptures sont exécutées en bois bien conservé: sans pourritures ni vermoulure. Seule, la figurine d'un ange au bouclier des armoiries est attaquée par des perce-bois ainsi que les deux billots sur lesquels se trouvent les groupes composés de trois

apôtres.

Il faut marquer, que les sculptures de retable ne sont pas toutes de même qualité du poit de vue artistique et technique, ce qui permettera à l'avenir de faire les conclusions déterminées au sujet de divers maîtres participant à exécution du retable; pourtant, même à présent, on peut remarquer les traits communs inhérants à toutes les sculptures en général.

Malgré certains inconvénients qu'on peut trouver presque dans chaque sculpture, et la composition un peu amorphe des oeuvres de la partie centrale, le travail des sculpteurs sur bois est remarquable par son maîtrise professionelle et le traitement soigneux des formes, faits presque sans tenir compte du modélé ultérieur lors de l'application de l'enduit. Les têtes bien taillées aux traits individuels des visages, de très belles lignes des cheveux, les vêtements drapés d'une manière libre et variée - tous ça temoignent d'un travail de haute qualité des sculpteurs sur bois.

Les bras, ou plus précisement, les mains de plusieurs sculptures peuvent être considérées comme parties les plus faibles, en comparaison avec d'autres éléments. Malgré son modélé bien fin, elles ne sont pas toujours incorporées d'une façon organique dans la construction anatomique de figure. Articulations, ongles, veines par exemple sont sculptés non seulement dans l'enduit, mais également dans le bois, et de même manière, très nette, semblable à celle du modélé du front, des yeux, du nez et de la bouche.

La surface du bois, dans l'endroits les plus importants des figures - visages, mains, vêtements - avant l'application de l'enduit, avait été couverte d'une toile de lin grossière d'armure de garniture. Les surfaces non couvertes de toile ne sont pas préparées pour reçevoir l'enduit, c'est-à-dire nulle parte, dans les lacunes sans l'enduit, nous ne voyons les traces de incisions, au contraire, la surface du bois y est lisse et bien polie.

L'epaisseur de la couche de l'enduit de colle et de craie qui couvre les sculptures, varie selon des endroits. Sur les visages, mains, vêtements cette couche est plus épaisse, que sur les attributs ou sur les côtés latérals et les envers de l'oeuvre. La présence de gouttes et de coulées de préparation sur les bases et à l'intérieur des sculptures montrent, que la colle n'était ni trop dense, ni trop liquide, et que lors de l'application de l'enduit les sculptures se trouvai-

ent en position horisontale aussi bien qu'en verticale. L'épaisseur inégale de la préparation avait été conditionnée par exigences différentes: par exemple, dans les vêtements à l'ornement gravé ou sur les mains et visages, couverts de rides et de plis, la couche de préparation devait être plus épasse, tandis que sur les larges surfaces des vêtements et des attributs, relativement planes, elle pouvait être moins épasse. Les cheveux sont modélés sur l'enduit d'épaisseur variable: de la couche la plus mince jusqu'à des couches épasses. Il convient de marquer une particularité de la préparation de cheveux: en profondeur elle est remplie de fibres de 2-3 cm et de petites soies de porc, qui servent d'armature originale. De la même manière sont fixées les couches de préparation dans les nombreuses parties rondes, telles comme les mains d'enfant dans le groupe de Sainte Anne. La préparation de toutes les sculptures du retable est solide, ne présente pas de clivage, cependant avant traitement elle se détachait dans plusieurs endroits.

Il s'agissait en tout premier lieu de fixer la préparation des sculptures et des détails d'architecture. A cette fin on a employé une dispersion aqueuse d'acétate de vinyle additionné d'éthylène (à 8-10%), qui penètre dans les micro-fissures et pores de la préparation sans difficultés; pour collage on a utilisé une autre dispersion aqueuse - le copolymère d'acétat de vinyle et 2-éthylacrylate de hexyl (AV2EAH, à 10-15%). Cependant, ces matières ne nous donnent pas toute satisfaction en raison d'une particularité de couches minces d'enduit de nos sculptures, a savoir lors du traitement par des composés aqueux l'enduit peut commencer à se gonfler. Cela incite à introduire le composé par petites doses, en tamponnant toujours la partie à fixer. Cet inconvénient dont le mechanisme n'est pas encore connu, nous amène à rechercher les autres matières à base de solvants organiques pour la fixation de l'enduit.

Polychromie et dorure. La dorure des sculptures est uniforme, l'or d'une teinte chaude est appliqué sur une ébauche rougeâtre, pas très sombre. Les feuilles d'or sont mises sur une surface bien préparée, et leurs joints sont aplanis à tel point, qu'il est difficile de définir leurs dimensions et l'ordre d'application. La dorure sur les fonds de volets et des détails architecturals, à en juger par l'aspect extérieur, ressemble beaucoup à celle des sculptures. Les cheveux de certains figures étaient également dorés; cette dorure

s'est conservée partiellement et permet de voir, que c'était l'or en feuilles, appliqué sur une préparation brune-rouge. La macle (l'or additionné d'argent) était appliquée sur l'endroits invisibles pour le public. A la suite d'oxydation complète de l'argent ces endroits semblent être peints en noir. On avait employé de l'argent pour la mise au point des attributs et les détails architecturals; dans ces derniers l'argent est mis sur l'enduit blanc ou sur une préparation de craie grisâtre. Dans bien des cas dans les attributs l'argent est mis sur préparation brune-jaune; il est devenu sombre presque entièrement et ne s'est conservé qu'en fragments. Le nettoyage de deux couches du vernis assombri sur la dorure, la macle et l'argent était réalisé au moyen des mélanges de solvants organiques à l'aide des compresses et tampons.

Couleurs principales de la polychromie. La polychromie des visages et des mains est appliquée en plusieurs couches, les couleurs "de chair" sont posées sur préparation rosâtre au dessin des veines des mains. Pour teindre les cheveux, les vêtements, les attributs des Saints et les détails architecturaux on avait employé des pigments sous forme de couleurs pures: le rouge - le cinabre à nuance framboise froide; le bleu - l'azurite sur préparation grise foncée, le blanc - le blanc de plomb, les ocres jaune et brune-claire, le vert-de-gris. Toutes les couleurs sont appliquées en une couche mince, sans moindres traces de pinceau. Après avoir peintes, les sculptures ont été couvertes de vernis, qui à présent est partiellement réuni du pigment vert. Nous croyons que ce vernis doit être seulement aminci et non enlevé complétement.

Polychromie des visages et des mains des sculptures. Dans la polychromie des visages et des mains on peut remarquer des procédés communs, apparus d'une façon plus nette dans les visages d'homme. Le style d'exécution des visages et des mains est assez réaliste, mais non sans un certain procédé conventionnel, qui se répète presque dans toutes les figures nettoyées. Sur préparations claire-orangeâtres ou rosâtres nous voyons les couches "de chaires", plus ou moins teintées en rose. Le rouge des joues, des ailes du nez, des articulations des doits et des coudes nus (demi-figure de Jean-Précurseur) est d'une teinte brune brique, plus prononcée en comparaison avec le rouge des joues, de menton et des mains pour la demi-figure de Sainte Barbe, où il est plus doux, d'une teinte froide. Les paupières supérieures et inférieures de toutes les figures sont soulignées par une teinte

rose foncée. Les paupières supérieures aux cils dessinés sont bordées d'une ligne sombre, tandis que les paupières inférieures - d'une ligne rose foncée; parfois cettes lignes se sont réunies au coin de l'oeil. Dans tous les visages d'homme on peut voir des rides rose-foncés, allant du coin extérieur de l'oeil au temple; parfois on peut observer les rides rose-foncés, qui viennent des coins intérieurs de l'oeil aux ailes du nez, ou encore, les rides sous les yeux, sur le front, sur la racine du nez. La polychromie des rides et plis est appliquée suivant leur microrelief, modélé dans l'enduit.

Les mains sont peintes de façon analogue: au moyen de la même couleur rose-foncée ou rose brique sont soulignés veines, petites fosses, rides, articulations des mains et les ongles. Le dessin de veines sous les couches de cartation présente une particularité supplémentaire de la polychromie des mains.

Les yeux de presque toutes figures sont peints de la même manière: le blanc de l'oeil - bleuâtre, l'iris - bordé de ligne foncée, la prunelle grande et sombre à point de rehaut de blanc de plomb, fréquemment à bordure fine blanche. La couleur des yeux des figures brunes - brune, de celles aux cheveux gris, claires et d'or - bleue foncée. Les lèvres de toutes les figures sont de la même couleur, que le rouge des joues. La couleur des cheveux des figures d'homme comprend plusieurs teintes: les nuances différentes du gris, du brun et le noir. Les limites entre les barbes et les chaires des joues sont estompées. Les sourcils et cils de presque toutes figures sont peints par la même couleur que les cheveux.

La polychromie des vêtements et des attributs présente une gamme de couleurs traditionnelles pour l'époque de haute gothique: des vêtements dorés aux doublures rouges ou bleues, aux revers et ornements répétant un motif de fleur ou de grenade. Les voiles sur les têtes des femmes sont blancs, les livres - ont des reliures vertes aux tranches rouges ou dorées; presque tous les piédestals des sculptures sont verts. On exécutait le dessin des détails fins du vêtement ou d'architecture au moyen de la couleur noire, parfois appliquée sur l'or ou l'argent. La polychromie originale s'est conservée assez bien. La couleur bleue - l'azurite sur la préparation grisâtre présente une difficulté particulière pour le nettoyage. A présent elle est très fragile et recouverte de couches de vernis et de surpeints postérieurs. Jusqu'à présent aucune des méthodes de nettoyage ne peut être considérée comme satisfaisante: ne

pouvant éviter complétement l'endommagement de la couche bleue originale, le dégagement des parties des vêtements peintes avec l'azurite est remis jusqu'au moment quand on trouve une méthode convénable.

Lors du nettoyage des sculptures les repeints à la détrempe de 1625, qui répètent la polychromie d'origine d'une manière simplifiée, ont été enlevés. Vue de ses qualités artistiques et techniques, ainsi que son originalité, on a réalisé une documentation photographique en noir et blanc et en couleur, ainsi qu'un dégagement des couches successives des visages et des mains.

<u>Répartition des sculptures dans le retable, technique de montage du retable, procédés de fixation des sculptures</u>.

Après avoir pris connaissance des sources écrites au sujet du retable de Talline, nous avons commencé à prêter une attention particulière aux détails de sa construction, étant donné un désaccord entre l'opinion admise et les faits révélés au cours de restauration du retable. Ainsi, un examen attentif du trône de la Vierge a montré, que sa construction n'a subi aucunes transformations du moment de sa fabrication et d'enplacement à l'intérieur du retable, tandis que, d'après une opinion rependue la Vierge sur trône était antrefois soulevée au-dessus des figures des apôtres environnantes. Quand on est sorti les figures des caisses latérales, on a vu derrière eux les zones de l'enduit blanc, sur lesquelles les contours des figures ont été entourés avec l'ocre brun. La manière à laquelle les figures avaient été clouées, nous montre, qu'on ne les a jamais tiré dans le but de renouvellement. Par cela donc des confirmations sur une rédorure des fonds des volets, aussi bien que sur une date postérieure des planchettes portant les noms des Saints, qui sont clouées aux piédestals spécialement taillés des grandes statues de volets se trouvent réfutées.

Les modes de fixation des sculptures au retable sont fonctiones du type de figures. Les statues rondes, éloignées des parois de fond, sont fixées au moyen d'un pivot inséré, d'un côté, dans le bois d'une statue et, de l'aute côté, dans la partie du retable qui la porte. Les autres sculptures sont clouées aux parois de fond par des clous forgés, passant à travers des parois dans le dos des oeuvres.

Après restauration des sculptures des volets, on a changé le mode de leur fixation. Les clous forgés qui

percaient auparavant la peinture du paroi de fond dans les caisses latérales, furent remplacés, après avoir mis les figures à leurs places anciennes, par des vis de laiton, passant à travers des planches épaisses de chêne transversales des volets. Les perforations anciennes dans les bases des sculptures ont été reutilisées pour des vis à filet conique. Chaque sculpture étant fixée au moyen de deux vis, toutes les figures sont stables, mais en vue d'exclure complétement toutes vibrations éventuelles de figures (suivant les mouvements des volets), les points des vis sont munis de filet métrique et de fixateurs.

La technique de montage du retable se caractérise par le fait que la mise au point soigneuse des sculptures et parfois ses dimensions ne sont pas conformes à celles d'encadrement architectural. C'est pourquoi nous voyons qu'en bien des cas les figures, déjà dorées et peintes, ont été un peu taillées, ou encore, dans les bases des sculptures il y a des planches supplémentaires; certains détails architecturals étaient égalément taillés pour qu'ils n'empêchent de mettre les sculptures précisement à leur place. Ce qui saute aux yeux, c'est que de nombreux détails du fond architectural, dorés et d'une remarcable finesse, sont fréquemment cloués par de grands clous forgés, bien qu'il y ait eu certainement la possibilité de les fixer d'une façon invisible. Les sculptures de la caisse centrale et du tabernacle, clouées par des clous au fond, témoignent du même "soin" exagéré de la stabilité des figures de la part des monteurs du retable. Actuellement, cettes sculptures mises sur leur place y sont maintenues uniquement pour le compte de leur propre poids.

Conclusion. Dans le présent rapport on a fait une tentative de présenter ne saurait-ce qu'une partie de l'information à propos de propriétés technico-technologiques du retable de Bernt Notke, Ces données ont été obtenues au cours de dégagement de la plupart des sculptures polychromes du retable, qui compte plus de 30 figures. À l'étape suivante de ce travail ces informations doivent être complétées et précisées à la suite d'un nettoyage de la polychromie de 6 figures de la caisse centrale et du décor architectural.

Étant donné l'importance du retable de Talline pour l'histoire des arts, nous avons l'intention de poursuivre nos études en appliquant des méthodes physico-chimiques d'examen modernes. Nous espérons, que les recherches détaillées du ratable permetteront de révé-

ler une série de procédés technico-technologiques constants, qui sont caractéristiques pour l'atelier de Bernt Notke.

Nous n'avons pas traité ces études dans ce rapport, parce qu'ils ne sont pas encore terminées. Les matériaux précieux qu'on recevera au cours de ce travail feront l'objet d'une communication particulière. A présent nous ne pouvons que citer les principales de cettes méthodes, pour donner une idée d'une large envergure de cettes recherches. Outre les photographies ordinaires et spéciales de restauration, en noir et blanc et en couleur, des informations supplémentaires seront obtenues grâce à l'étude radiographique. Pour l'examen des matériaux de sculpture on recoure à la spectrométrie d'emission à l'aide du micro-analyseur de laser, à l'analyse structurale aux rayous X, à l'analyse microchimique, à la chromatographie et à la spectroscopie-IR.

A SCIENTIFIC EXAMINATION OF SOME 19TH-CENTURY DUTCH GOTHIC REVIVAL POLYCHROMED SCULPTURES

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Abstract

Two polychromed reliefs dated 1873 and two altar-cases with late 19th-century polychromed sculptures were examined. Pigments identified include Prussian blue, synthetic ultramarine, red iron oxide, chrome green, barium yellow, vermilion, gold and aluminium leaf. It appears that the Gothic revival polychromed sculpture examined is not a close copying of medieval examples in the technical sense - considerable freedom and sophistication were employed to obtain various effects.

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1. Introduction

The Gothic revival was introduced in the Netherlands only in the second half of the nineteenth century. Two separate schools can be recognized in Dutch neo-gothic. The first centred in Amsterdam, was dominated by the architect P.J.H. Cuypers, the Utrecht School was much influenced by the priest Van Heukelum (1).
Van Heukelum introduced German artists for the furnishing and decoration of these new Roman Catholic churches. Among them was Friederich Wilhelm Mengelberg born in Cologne in 1837. Mengelberg established a large workshop, responsable for the majority of neo-gothic sculptures in the Netherlands.
In recent years a renewed interest in the architecture and art of the 19th century has developed leading to a counter-reaction to the progressive destruction of monuments from that century. The materials and technique of 19th-century polychromed sculpture would not seem, however, to have received much attention.
While some evidence on the techniques used in polychromed sculpture could perhaps be extracted from contemporary sources (2) and the archives of the Mengelberg family

may contain much information, it has not been the aim of the present study to evaluate these potentialities. Rather, the examination of the objects themselves has been taken as a starting-point. Such examinations may be divided roughly into (a) technical examination with the human eye and magnifying glasses and (b) scientific examination using such laboratory techniques as paint cross-sections and microchemical analysis of pigments. A certain number of polychromed sculptures in the Netherlands were studied only with the simple means of category (a). Some observations are reported in section 2. It was possible to examine in detail four scenes stemming from different altarpieces now in the Archi-episcopal Museum in Utrecht, and to collect and study paint samples from these. The results are discussed in sections 3 and 4.

2. Sculptures in the S. Franciscus Xaverius 'De Krijtberg', Amsterdam

This church, built by A. Tepe from 1881 to 1883, has preserved all its original furnishings including a great number of polychromed altarpieces and other sculptures, showing a diversity of quality both in aesthetic and in technical respects. The pulpit is a remarkable neo-gothic structure polychromed in an even extraordinary technique. In many respects the polychromy seems to be inspired by medieval techniques, but the actual execution is quite different. Patterns on bole gilded gold-leaf, for instance, have not been made by scratching into a layer of paint applied on to the gold, as would be the usual technique in earlier polychromy, but are painted, thus reversing the effect. Another difference from medieval practice is the treatment of the surrounding structurally relevant carpentry, where rosettes in red and blue are directly applied to the unpainted oak wood and left without a ground, using probably stencils.
The Mary-altar shows the use of applied brocade rims on the robe of Mary, and of rosettes, probably of metal. Similar rims are found on the altarpiece from Maarssen (section 4). While applied brocades were a customary asset of medieval polychromed sculpture and patterns in relief made in moulded gesso (3) or sometimes in wood were known in painting, it seems that there is no direct parallel of these rims in medieval polychromed sculpture (4). That considerable technical variety could be achieved is exemplified by a figure of Christ at the left of the entrance in the same church, where in the brocade of the robe a pattern is incised with a blunt tool; the centre of the pattern is polished 'gold' (5), the surrounding area is dull,'gold' and red striations on 'gold' fill the transitional areas. This indeed is a 'revival' of the medieval use of employing the contrast between polished

and matt gold but transposed into a new idiom. In this sculpture the inner part of the upper garment is decorated with 'gold' or 'bronze' paint stripes on a blue background, again deviating considerably from medieval practice.

3. Two reliefs dated 1873 from Pannerden

The two reliefs, The Betrayal of Judas and the Three Marys and the Angel at the Tomb (6), are probably carved from linden wood; the frames and the background are oak. This would point to a curious compromise between traditional practice in Germany and the Netherlands. Linden wood was predominantly used in medieval wood-carving in Germany. In the Netherlands oak was most popular (7). The chromatic appearance of the two reliefs is somewhat hard, especially in the green and blue colours. This is clearly due to the use of pigments which were not only found to be non-medieval but are also of a very fine particle size. The coarsely ground azurite used in medieval polychromed sculpture cannot be imitated in texture in this way.
The decoration of the hems of various robes appears to be 'underdrawn', probably with pencil.
The inner part of the under garment of the woman at the right in the Three Marys relief is painted red on green in the lower parts of the folds. This could be an imitation of the red bole which is frequently seen in such areas in medieval sculpture.

Investigation of samples and preparation of paint cross-sections (8) showed that the ground (chalk with glue) is impregnated with an oleaginous medium (9) and covered with a white layer (white lead in an oleaginous medium). This technique of isolating the ground to prevent penetration by the overlying oil paint and the addition of a white layer to increase the luminosity would seem to stem rather from medieval painting techniques than from those of polychromed sculpture. The use of the white layer here is not quite clear because the paint used is rather opaque.
The paint layer structure is further simple: normally a single layer is encountered on the white layer. The pigments, used in an oleaginous medium are:

- blue: : synthetic ultramarine with barium sulphate as extender; Prussian blue. A sea-green tone is obtained by mixing Prussian blue with synthetic ultramarine.
- violet: mixture of synthetic ultramarine and red iron oxide.
- green: chrome green. A glaze over the wings of the Angel contains probably viridian. A whitish green in the robe of Judas is

obtained by applying a layer of chrome green over a layer of barium yellow. A lighter green is obtained by mixing chrome green with synthetic ultramarine.

- red: vermilion, mixed sometimes with a red organic dyestuff precipitated on aluminium hydrate.
- white: lead white.
- metallic leaf: gold, aluminium. (A yellow mordant containing oil is used.)

4. Altarpiece from the Roman Catholic church in Maarssen

The dismantled altarpiece from the Holy Heart church, consecrated in 1885 and built by A. Tepe (10), is now preserved in the Archiepiscopal Museum, Utrecht. It consists of three altar-cases of which two, the Lamentation and Mary and the Child with S. Dominic, have been examined.
The backs of the two altar-cases are painted with angels and stencilled stars and rosettes respectively. The side planks are left unpainted and rosettes are applied directly on the oak. The unpainted oak frame of the Mary and Child with S. Dominic is provided with rosettes in prefabricated relief. The hem of Mary's robe shows a relief in which imitation jewels are glazed in red and green. Analysis showed that this relief consists of gold leaf on chalk without any lead white. The green glaze is Prussian blue in an oleaginous medium.

The gilded robe of Mary in this scene shows a matt layer of a glue-like substance (not analysed). This might be intended to tone down the brilliance of the polished gold leaf and would thus connect with a medieval practice (11).
The colour scheme is limited, and there are fewer pigments used in the polychromy. No white layer on top of the ground was encountered as in the two reliefs; the ground, however, is heavily impregnated with an oleaginous medium.
The following pigments could be identified by microchemical analysis:

- blue: Prussian blue on a white inert.
- green: Prussian blue sometimes mixed with a little vermilion.
- red: vermilion, red organic dyestuff precipitated on aluminium hydrate.
- white: lead white.
- metallic leaf: gold, aluminium.

In the blue robe of Mary in the Lamentation two layers are encountered. The red undergarment of this figure shows also a more complex paint-layer structure, with two layers containing vermilion and a glaze of a red

organic dyestuff. The white head-scarf and the flesh-colours are two-layered as well. The ground is again chalk without admixture of lead white. The variety of pigments is more restricted in this altarpiece.

5. Conclusions

The pigments identified in the sculptures examined are all quite compatible with the last quarter of the 19th century and would have been easily commercially available at the time. Although some of the techniques used in polychroming the sculptures still show affiliations with medieval practice, no attempt has apparently been made to use medieval pigments (12). The use of aluminium leaf as a substitute for silver illustrates this.
There is somewhat more variety in pigments in the two reliefs dated 1873 and the paint-layer structure in these reliefs is not identical with that found in the Maarssen sculptures. It is known that Mengelberg used different collaborators for polychroming, and such individual distinctions might well be reflected in the technical execution.
It would seem that the revival of medieval polychrome sculpture was certainly not a close copying of examples in the technical sense, and considerable freedom and sophistication were employed to obtain various effects. The preliminary character of this study does not allow further generalizations. It is hoped that it may contribute to increasing the interest in 19th-century polychromed sculpture which is at present rather neglected both as a cultural phenomenon and as an interesting phase in the history of painting materials.

Acknowledgements

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Notes and references

(1) H.L.M. Defoer, 'De Utrechtse Neogotiek en het Aartsbisschoppelijk Museum', Forum, XXIV-1 (1973), 4-12. Cf.also H.P.R. Rosenberg, De 19de-eeuwse kerkelijke bouwkunst in Nederland, Staatsuitgeverij, 's-Gravenhage 1972.

(2) E.g. Het Gildeboek, Tijdschrift voor Kerkelijke Kunst en Oudheidkunde, Utrecht, J.L. Beiers, J.R. van Rossum, 1877, 2e deel, p. 101 ff.; John Kühn, Ueber die Bemalung der Kirchen, Leo Woerl Verlag, Würzburg 1893; G. Jakob, Die Kunst im Dienste der Kirche, Landshut 1908; Stephan Beissel, S.J., Die Bauführung des Mittelalters, Herdel'sche Verlagshandlung, Freiburg im Breisgau, 1889. This literature was kindly brought to the attention of the author by H.L.M. Defoer.

(3) Cf. Cennino d'Andrea Cennini, Il Libro dell'arte, Chapter CXVI and CXXV.

(4) Reminiscences of metal sculpture could perhaps play a role here.

(5) The sculptures described in this section have not been chemically analysed; the word 'gold' and 'bronze' should thus be taken as a visual impression, not as an established fact.

(6) Archiepiscopal Museum, Utrecht, Inventory No 626. The reliefs are from the Roman Catholic church at Pannerden. Signed with the Mengelberg monogram and dated 1873; both carved in the lower part of the relief.

(7) See, e.g., J. Taubert, 'Plastik', in: Keysers Kunst und Antiquitätenbuch, Keysersche Verlagsbuchhandlung, München 1970, Vol. I, p. 344.

(8) Paint cross-sections were prepared by embedding the samples, after preliminary inspection under a binocular stereomicroscope, in a polyester resin (Buehler Castolite 20-8120 with hardener 20-8122). The specimens were sectioned and then ground with silicon-carbide paper, grades 200, 320, 400 and 600, with water as a lubricant; brief polishing with 5 micron alumina on a napless cloth was usually sufficient. Cross-sections were studied with a Zeiss 08 Standard microscope in dark field reflected light. Microchemical analysis was generally carried out according to J. Plesters, 'Cross-sections and Chemical Analysis of Paint Samples', Studies in Conservation, 1 (1956), 110-157. For mercury the reaction with cobalt acetate and potassium thiocyanate as described by R.J. Gettens, R.L. Feller and W.T.

Chase, 'Vermilion and Cinnabar', Studies in Conservation, 17 (1972), 45-69, was used in addition to the sodium azide/iodine test.

(9) Staining tests with Sudan Black B and Ponceau S were carried out adopting the scheme used by M. Johnson and E. Packard, 'Methods for the Identification of Binding Media in Italian Paintings of the 15th and 16th Centuries', Studies in Conservation, 16 (1971), 145-164. Instead of cross-sections, however, thin sections were used as advocated by M.C. Gay, 'Essais d'identification et de localisation des liants picturaux par des colorations spécifiques sur coupes minces', Annales Laboratoire de Recherche des Musées de France, 1970, 8-24. The thin sections were prepared by simply embedding the sample in dentist's wax with a heating spatula and cutting with a razor blade under the binocular microscope.

(10) H.P.R. Rosenberg, *op. cit.* p. 141.

(11) M. Broekman-Bokstijn, J.R.J. van Asperen de Boer, E.H. van 't Hul-Ehrnreich and C.M. Verduyn-Groen, 'The Scientific Examination of the Polychromed Sculpture in the Herlin Altarpiece', Studies in Conservation, 15 (1970), p. 380.

(12) E.L. Richter and H. Härlin, 'The Pigments of the Swiss Nineteenth-Century Painter Arnold Böcklin', Studies in Conservation, 19 (1974), 83-87, have reported such historic pigments as azurite and natural ultramarine in a pigment collection from the heritage of this painter and attribute this to his interest in historical painting techniques. Red lead as identified by these authors was identified during the present study by the author in one of the painted angels on the back of the altar-case of the Lamentation. Richter and Härlin consider the use of this pigment historic, as it has been found mainly in romanesque works of art.

DOCUMENTATION: PREPARING FOR THE ELECTRONIC COMPUTER

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In previous reports to the Documentation Group of the Conservation Committee, attention has been drawn to the advantages of feature card systems for indexing information on the conservation and scientific examination of museum objects. In particular these systems are very useful in cases where the total number of objects involved is less than about 10,000 items. They are therefore of special interest to smaller museums and galleries. For very large numbers of objects, the feature card system presents difficulties arising from the finite number of index positions on the feature card and although these difficulties can be overcome to some extent by the use of additional card systems, the search procedures then become more time consuming. Another disadvantage of the feature card system is that, unlike a simple card index, it is not able to deal satisfactorily with the problem of locating information by reference to the name by which an object is generally known (as, for example, "The Canterbury Brooch"). For this reason it is often advantageous to maintain a separate card index in parallel with the feature card index. Again this involves extra manual work.

The electronic computer provides a means by which information may be stored and processed so as to avoid the disadvantages of these simple manual systems. Data can be stored in a much more compact form than on cards and the manual work involved in maintaining and using the system is reduced to little more than the initial collection and entry of the data, for once it is in the computer, the operations of sorting, listing, checking, etc., can be done by the computer at very small extra cost. Thus it is clear that as computers come into more widespread use in museums they will inevitably replace manual systems of information retrieval.

There are, of course, many museums, particularly the smaller ones with considerable problems of cataloguing and information retrieval and with little prospect of using a computer in the foreseeable future. In these cases, card systems must still be considered as the best means of dealing with these problems. However, in adopting any new card system it would be wise to give some consideration to eventual computerisation of the data and if possible adopt a system whichwill avoid difficulties when the data is eventually transferred to a computer.

Unfortunately this procedure in itself is fraught with difficulty, for computers must be presented with structured data, otherwise they cannot manipulate it. That is to say, they must be told explicitly what each item of data represents. Thus, unless something is known about the computer system which will eventually be used to replace the card system, it is very likely that the structure of the chosen card system will be incompatible with the computer system, necessitating extra work in re-structuring the data when it is entered into the computer system.

A similar complication arises when considering the possibility of the transference of data between different computers, due partly to differences in the data structures of different data management systems and complicated by differences in the internal characteristics of different computers.

However, it would seem that, apart from the practical and financial difficulties involved in creating a network of museum computers, one must ask whether in fact such a linkage is really necessary. The answer to this question must surely be no, for most enquirers for information are quite happy to obtain answers to their questions within a few days. Thus providing each museum maintains its own efficient documentation and information retrieval system, replies to requests for information can be dealt with quite satisfactorily through the normal channels of communication.

Thus the principal problem for the card users in attempting to plan for eventual computerisation lies in choosing a card system which will be compatible with the chosen computer. Unfortunately this implies a fore-knowledge of the computer system which will eventually be used - a state of affairs which is not always possible, particularly for those museums where the changeover to a computer system is likely to take place at a rather indeterminate date in

the future.

Where the computer to be used is known, the problems are not too great. In many cases there will be available a data management system, perhaps intended primarily for business purposes, which can be used with the minimum of modification. There are also now available or under development, a number of data management systems, specifically designed for museum purposes, which could be used on a suitable computer, e.g. the SELGEM system which has been developed at the Smithsonian Institution.

SELGEM is a group of programmes written in COBOL from which can be selected an appropriate combination to suit the needs of the user. It requires a minimum computer configuration of 4 tape drives, 20,000 characters of core and a COBOL compiler and has been run in computers such as the Honeywell 2015, IBM 360, CDC 3100, CD6 6400, UNIVAC 1110, GE 635 as well as Burroughs and ICL machines. Details can be obtained from The Manager, Information Retrieval and Indexing, Information Systems Division, Smithsonian Institution, A. and I. Building, Room 2363, Washington, D.C. 20560.

In the U.K, the Information Retrieval Group of the Museums Association (IRGMA) have been actively concerned since 1967 in finding a solution to the problems of documentation and computerisation. They have produced a Museum Documentation Standard which is a set of rules by which data can be stored and manipulated in a computer. These are sufficiently comprehensive to allow all possible information on a museum object to be recorded to any degree of detail to which a curator or research worker may require. Based on this they have also produced a Museum Data Standard to fulfil the practical requirements of recording in museums. This work has led to the development of a number of basic record cards (size A5) for various types of museum collections. These cards are designed for manual filing systems but as they are compatible with the IRGMA Documentation Standard, their contents can later be transferred to and manipulated by a computer which is programmed to deal with them. To this end computer programmes are under development for this purpose. It should also be pointed out that since the IRGMA standard employs a keyword concept the cards are compatible with the use of a feature card system too for the indexing and retrieval of the information they contain.

The IRGMA system does not neglect the needs of conservation and indeed the design of cards specifically for this purpose is being actively pursued by a joint committee of IRGMA and the U.K. Group of IIC. It is expected that the results of

their deliberations will be available later this year.

In addition to and independant of the work of this joint committee, work is in progress in the British Museum Research Laboratory on the development of an information storage and retrieval system for use with a small computer. This system, designated BMUSE is based on a similar hierarchical structure as the IRGMA system and will be compatible with it.

SUMMARY

In this short paper an attempt has been made to point out some of the factors which must be taken into account in preparing for the impact of computer facilities on manual, card-based, information retrieval systems. Some indication has also been given of various ways in which these problems might be overcome including the use of systems specifically designed for museum use.

ABSTRACT

The electronic computer presents a means by which information on museum objects can be stored, sorted and processed so as to avoid many of the disadvantages of simple manual card systems. However, the transition from a manual to a computer based system can prove quite difficult and costly in certain circumstances. This paper indicates the difficulties and points out some possible ways in which they can be avoided.

A DRAFT OF THE DOCUMENTATION SYSTEM CONCERNING THE RESTORATION OF A PAINTING OR SCULPTURE

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The question whether a restorer's work is a work of art or not has very often been subject to many discussions in the professional world, resulting mostly in the conclusion that the artistic component is the basic feature of this work though the restorer cannot solve the problems of restoration without a scientific approach.

In our country a restorer's work is classified by a law as the work of an artist with all the rights and obligations.

The artistic component involves the understanding and grasping of the essence and idea of the work of art. The scientific component of the restorer's work must in addition to artistic and historic views master in detail not only the development of the technique of the work of art to be restored /e.g. retouch/ but also the chemical and physical qualities of both original and new materials used. The third component is the restorer's skill controlled by the artistic and scientific components of the restorer's work. All the three components of the restorer's work result in the actual restoration of the work of art.

The above mentioned three aspects correspond also to what is expected of a restorer. The public and the owner of a work of art expect a technically perfect

restoration, i.e. that the restorer will from the artistic point of view understand the intention of the author of the work of art in question and will preserve its style, and that he will - from the scientific point of view- identify the original technique and determine the correct techniques for the restoration work to be carried out.

It is clear that every intervention by a restorer involves a certain danger for the work of art and adds to the restorer's responsibility.

The restorer's responsible approach to the work cannot be subjective only but must be considered and evaluated objectively, i.e. it must be properly described and documented from the first findings to the final result. That should not mean vast heaps of paperwork but brief, precise and clear records of the progress of the work and the final protocol with corresponding documentation.

Proper documentation contributes also to the scientific result of the restorer's work as no restorer lives in isolation but must necessarily make use of the results of the work of his predecessors and his colleagues and is therefore under the obligation to place the results of his work at their disposal. Without fulfilling this duty he could not be a restorer, i.e. artist and scientist in one person.

Scientific work must predominate in the records, since the recordered scientific results enable their future use by other restorers and help them avoid possibl errors. A true scientist is not ashamed of his mistakes and failures and will point them out to his successors.

Any "secret of the creative work" of a restorer is absurd.

The necessity of the recording of the restorer´s work is generally recognized in the world. Not always, however, do restorers know to what details such documentation should refer and not everywhere has such recording been required by law. There is, however, a general tendency - according to professional press reports - that documentation should be recorded in great detail and that its conceptions and forms should be normalized so as to make possible the scientific evaluation of a greater number of cases and more generally valid conclusions.

The possibility of mutual communication among individual workers, provided by the development of mass media today, necessarily makes professional workers throughout the world try to record the results of the work of restorers by means of information media and computers.

Data category

A
Number of dokumentation and files

B
Description of the work to be restored
a/ name
b/ author
c/ time of origin
d/ place or area of origin
e/ shape and dimensions
f/ technique
g/ the reverse side
h/ state of the work before restoration

C

Owner of the work

a/ owner

b/ who is authorized to decide about the work to be restored

c/ place where the work is permanently deposited

d/ History of the ownership of the work

D

Restoration order

a/ who orders the restoration

b/ date of order

c/ reason of order

d/ extent of the work ordered

e/ original term of restoration work

f/ changes in the order, term extension, partial deliveries

E

Restorer's findings

a/ background or basic material

b/ background

c/ the painting - surface

microscopic, chemical and physical analyses of the material before restoration
1/ basic background
2/ lower layer
3/ paints
4/ paste of paints
5/ varnishes
6/ former conservation means
7/ has the original work been covered by another painting ?

F

Material used for conservation

G

Cronologic description of the restorer's work

H

General conclusions and findings of the restorer

a/ concerning the material used for the original painting and the restoration work,

b/ concerning the techniques of the original author of the work

c/ concerning historic and technological relationships

I

List of sub-suppliers

K

List of reference literature concerning

a/ the work itself

b/ artistic and historic problems involved in the restoration of the work

c/ technical and technological questions

L

List of enclosures

M

Personal data of the restorer

Date   Signature of restorer

EMPLOI DE CARTES PERFORÉES POUR LE RASSEMBLEMENT ET LE TRAITEMENT DES RENSEIGNEMENTS DE SOURCES ÉCRITES ANCIENNES SUR LA TECHNIQUE ET LES MATÉRIAUX DE LA PEINTURE

Propositions préliminaires

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1. Introduction

Un grand nombre de manuscrits, contenant des renseignements sur la technique et les matériaux de la peinture sont conservés dans de nombreuses bibliothéques, archives, collections d'Etat et privées de divers pays. Ce n'est qu'une partie insignifiante d'entre eux, qui avait été publiée, et certains de ceux derniers sont publiés seulement en fragments. Bien que les manuscrits isolés étaient à plusieurs reprise réédités et traduits en langues différentes, la plupart de cettes éditions tout de même sont une rareté bibliographique.

Il faut signaler, que si nous connaissons des tentatives assez heureuses d'une systématisation des traités publiés dans le passé et des éditions scientifiques des manuscrits (1), les textes inédits, inversement, n'étaient jamais classés d'une manière semblable. Ce qui était fait tout au plus, c'est un aperçu de certains d'entre eux dans les bornes d'une collection (2). De nombreux matériaux d'une grande importance potentielle en qualité de sources d'information sur l'histoire de la technique et de la technologie de la peinture sont donc connus, dans le meilleur cas, par un nombre très restraint de personnes et se trouvent inaccessibles pour de larges milieux de spécialistes.

Si nous pouvons juger aujourd'hui d'une manière assez complète des matériaux publiés et, dans une moindre mesure, de ce qui pourra être trouvé dans les bibliothèques et les archives, au contraire les recherches comparatives des données contenant dans cettes sources,

restent jusqu'à present non réalisées. Nous croyons qu'un tel travail est au-dessus des forces d'un chercheur solitaire. Ce n'est certainement pas un hasard, que mémes des ouvrage fondamentaux, tels comme ceux de Merrifield (3), Eastlake (4), Berger (5) et d'autres sont incomplets, et, de ce fait, contraditoires et asse vagues.

Il semble qu'à l'heure actuelle il y a de conditions nécessaires pour un recommencement, à l'échelon plus haut, des études textologiques des sources écrites ainsi que pour une systématisation des informations fournies par eux. Un travail collectif des spécialistes des pays différents, réunis dans les cadres du Comité de la conservation de l'ICOM, doit être mis à la base de cettes recherches.

2. Orientation et organisation du travail

Les activités des membres du groupe de travail sont formées de principals opérations suivantes, qu'on fait parallèlement: rassemblement et systématisation des informations, sa conservation et traitement.

Les informations réunies, en forme de photocopies, xérocopies et microfilms, se sont distribuées parmi les membres du groupe de travail à la base d'échange. Les informations traités, se sont livrées en forme de rapports, de communications et de publications des membres du groupe de travail ainsi qu'en forme de rapports généralisés (compte rendus) du coordinateur. Nous espérons, qu'avec le temps un fonds central du rassemblement des informations sera créer dans les cadres de l'ICOM.

3. Rassemblement et systématisation des sources

Les membres du groupe de travail rassemblent et systématisent des sources écrites (des manuscrits inédits en premier lieu), qui étaient crées ou qui se trouvent actuellement sur le territoire de leur pays selon le shcéma suivant:

1. Manuscrits concernant la technique et les matériaux de la peinture, écrits en n'importe quelle langue, et qui n'étaient jamais et nulle part publiés auparavant.

2. Manuscrits de n'importe quel contenu, en n'importe quelle langue, comprenant les renseignements relatif à la technique et aux matériaux de la peinture, non publiés jamais et nulle part auparavant.

3. Publications d'auteur, parues dans le pays et en langue du membre du groupe de travail.

4. Ouvrages de n'importe quel contenu, publiés dans le pays et en langue du membre du groupe de travail, comprenant des renseignements relatif à la technique et aux matériaux de la peinture.

5. Publications scientifiques des ouvrages, restés en forme de manuscrits.

6. Rééditions ultérieures ainsi que publications avec une appréciation critiques des ouvrages, indiqués dans les paragraphes 3-5.

7. Publications, dans le pays et en langue des membres du groupe de travail, des sources étrangères, indiquées dans les paragraphes 3-5.

8. On peut également rassembler les renseignements portant sur les sources publiées à l'étranger, toutefois il serait plus rationnel de les compléter au moyen d'échange avec d'autres membres du groupe.

On consignera tous ces manuscrits et publications révélés sur les cartes à perforation marginale, où on écrit, par texte ouvert, le dénomination complet d'une source, en respectant les règles de description bibliographique: (auteur, titre, ville, pays et date d'édition, et pour les publications rares et les manuscrits - emplacement avec indication de la cote du dépôt).

Au revers de la carte perforée des notes de toute sorte peuvent être faites, ce qui est surtout important en ce qui concerne des sources, indiquées dans les paragraphes 5-7, lesquelles nécessitent des remarques au sujet du caractère d'édition, de ces qualités, défauts et d'autres particularités.

Quant aux sources, écrites dehors du pays, il serait utile de donner, sur côté face d'une carte perforée, la traduction du titre en langue natale, et, inversement, pour le titre traduit - le ramener en langue de l'original.

3.1. <u>Système de l'indexation</u>

Pour garder les informations recueillies on peut utiliser des cartes à perforation marginale à un rang ou binaire, qui ont l'angle droit supérieur coupé, et mesurent de 146 x 206 mm environ.

Tant que le nombre de sources réunies n'est pas grand, on peut se servir de cartes perforées conforme-

ment aux principes de travail avec des fiches de catalogue, en les mettant dans une séquence commode pour l'opérateur. Cependant, au fur et à mesure d'accumulation des matériaux, il sera plus difficile de retrouver une source nécessaire ou un groupe de sources, unifiées par une ou quelques indices.

A cette étape, il serait raisonnable de procéder à une codification des indices sur cartes perforées. A ce but on compose une carte-clé à l'aide de laquelle on trouve rapidement des cartes à perforation nécessaires dans un massif.

On propose de coder cinq indices principales:

1. Auteur de l'original ou titre de source anonyme.

2. Date de création de l'original et d'autres éditions; voir par. 3.

3. Caractère de la source.

4. Lieu de création de l'original.

5. Langue de l'original et d'autres éditions; voir par. 3.

Seule la première de ces indices est codé d'après le sistème de clé combinée en quantité de 999 numeros, tandis que les quatre autres sont décodées au moyen d'une clé droite d'après la carte-clé (Fig. 1).

Il est nécessaire de coder l'auteur ou le titre de l'oeuvre anonyme, car dans certains cas une confrontation des recettes de listes différentes d'une même source ou encore, une comparaison des interprétations du même passage dans de diverses éditions critiques, les traductions différentes etc. peuvent être très importantes.

La date doit être codée pour qu'on puisse reveler rapidement des sources, crées dans la même époque.

Le lieu de création et la langue de l'original doivent être codées pour des raisons analogues. La codification du caractère de source aide à trouver vite des publications d'auteur, publications scientifiques, manuscrits, rééditions, traductions etc. dans une masse de matériaux réunis.

3.2. <u>Introduction des informations dans le système</u>

L'introduction des informations dans le système se fait au moyen du coupement en dehors d'une encoche qui conforme à une indice déterminée. Par exemple, imaginous que nous avons une carte perforée, sur laquelle

est inscrit le traité de Raphaël Borguini "Il Riposo", crée en Italie en 1584; on coupe des perforations en dehors de manière suivante: en haut (selon le code, indiqué sur la carte), - le numéro de Borguini, conformement à la liste dont possède l'auteur du ficher (la séquence dans la liste peut être n'importe quelle); à droite - une encoche sous laquelle est écrit "XVI siècle"; en bas à gauche - une encoche "Italie"; en bas à droit - une encoche, qui conforme au caractère de source traitée (édition d'auteur, réédition, traduction etc.), dans le cas s'il ne s'agit pas de l'édition d'auteur, à droit on coupe une encoche qui conforme à la date de publication; à gauche - une encoche qui conforme à la langue de l'original ou à celle de l'édition en question.

3.3. <u>Conservation des informations</u>

On garde les cartes perforées dans les fichiers spécials, ou dans n'importe queles boîtes, de façon qu'ils soient debout avec l'angle coupé - en haut à droite. L'ordre successif des cartes perforées peut être n'importe quel.

3.4. <u>Réception (livraison) des informations</u>

On prend un jeu de 100-200 cartes d'un massif de cartes perforées, on l'égalise sur la table ou dans un dispositif spécial, et ensuite, à l'aide de la carte-clé, en introduisant une aiguille d'acier dans une perforation nécessaire et en faisant secouer le jeu de cartes, on extrait des cartes contenant des données, conformément au but des recherches. S'il faut recevoir les cartes selon deux ou quelques indices, codées d'un côté de la carte, on utilise deux ou un certain nombre d'aiguilles.

Supposons par exemple, qu'il est nécessaire de trouver toutes les éditions, liées au nom d'Héraclius: premières publications, rééditions, traductions etc. Admettons qu'Héraclius a le numéro 18 dans la liste de code. On agit comme suit: dans la première zone de la carte-clé perforée (on l'avait fait coïncider au jeu à traiter) on introduit les trois aiguilles (fig. 1): la première - dans perforation "0 de centaines", la seconde - dans celle "1 dizaine" et enfin, la troisième - dans "8 unités". Après avoir secoué le jeu, nous recevous toutes les cartes contenant une indication à la publication du traité d'Héraclius.

Si nous avons besoin seulement d'éditions du traité, publiées en anglais, dans ce cas il faut introduire une

aiguille dans les cartes tirées lors de première opération, dans la perforation "anglais" de 5^{e} zone.

Si nous voulons limiter le nombre de cartes au XX^{e} siècle par exemple, alors il faut introduire l'aiguille dans l'encoche appropriée de 2^{e} zone. Des cartes tombées au cours de cette opération seront conformes à des fins de nos recherches.

On fait de la même façon, en combinant un certain nombre d'aiguilles et de perforations, pour obtenir n'importe quelles combinaisons des indices. Opérations fini, on remet les cartes utilisées dans le massif en n'importe laquelle séquence.

On trouvera les renseignements plus détaillés au sujet du travail avec cartes perforées de ce type dans le rapport du même auteur, présenté à la réunion plenière du Comité de la conservation à Madrid (1969) (6) ainsi que dans le rapport de J.Plesters, présenté également à la même réunion (7).

4. Traitement du contenu des sources

Le rassemblement et la systématisation des sources ce n'est qu'une partie préalable, bien que nécessaire, du travail. Le but principal consiste à leurs études et traitement ultérieurs.

Après avoir vu l'apparition des premières cartes perforées dans le massif, on peut procéder au traitement des sources. La première étape consiste à consigner toutes les indices technico-technologiques, tirées de chaque source, sur des cartes perforées isolées, sans prendre en considération le contenu de ces indices. Il serait recommandé l'ordre d'enregistrement suivant:

Dans la partie supérieure d'une carte perforée seront inscrits: auteur, titre d'ouvrage, date et lieu de sa création. Dans le cas où il s'agit pas d'une édition d'auteur, mais par exemple d'une réédition, d'une traduction etc. ces données seront complémentairement indiquées entre parenthèses (par exemple, M.Merrifield. Original Treatisses ... v. 2, p. 350). Pour des manuscrits inédits on indiquera le lieu de leur conservation et la cote du dépôt.

Ensuite, une photocopie ou xérocopie du texte de chaque paragraph ou du chapitre d'ouvrage en question sera recopiée à la main, complètement, sans coupures, en langue de l'original, soit sera dactylographiée ou encore collée.

Si le texte traité est écrit en langue d'opérateur, il faut, après cet originale, mettre sa traduction. Dans certains cas, quand la source est traduite sur langues différentes et quand dans les traductions il y a des variantes de sens, ils doivent être obligatoirement marquées soit sur une carte perforée isolée, soit sous la forme de notes au dos de la carte maîtresse. Les variations d'interpretation du texte dans les diverses éditions y peuvent être également marquer. La dernière note se rapporte non seulement à différents passages d'un texte, mais à tout un ouvrage dans son ensemble (par exemple, les questions d'attribution, de datation etc.)

4.1. <u>Système d'indexation</u>

Les cartes à perforation marginale binaire, décrites dans le paragraphe 3.1. peuvent être employées pour le traitement des informations réunies; sur elles on fait le code des trois principaux groupes d'indices:

1. Caractéristique générale d'un texte (auteur ou titre de source anonyme, de laquelle un passage en question est tiré, date et lieu de création).

2. Groupe d'indices, permettant recevoir des informations généralisées sur la description de l'originalité structurale de la peinture (espèce de la peinture, technique, support, préparation, dessin, couche picturale et protectrice).

3. Matériaux du support, de la préparation, du dessin, de la couche picturale et protectrice.

Toutes ces indices ennumerées, à l'exeption de 1ère (Auteur...), 3ème (Matériaux...) et 10ème (Lieu de création de l'original) sont codées à l'aide de la clé droite, tandis que les signes des zones 1er et 3eme - au moyen de la clé combinée, grâce à quoi ils peuvent comprendre le contenu de 999 sources et, conformément, le même nombre de dénominations des matériaux. Les indices de 10e zone sont codées selon le système de la clé comdinée 1-2-4-7 et permettent faire le code de 29 dénominations (fig. 2).

Une telle classification d'indices permet facilement et assez vite (en vue de volume d'informations à réunir) recevoir des informations relatif à n'importe quel élément (ou éléments) de structure d'un oeuvre de peinture, aussi bien isolées que corrélées avec une autre ou quelques autres indices. Citons, en tant qu'exemple, les recettes de la préparation de vermillon isolées ou en

corrélation avec une date déterminée et (= ou) un pays; ou bien, le dessin - avec un matériel, pays, date etc.

Si nous voulons élargir le volume d'information à introduir, en suivant une méthode de codification la plus simple, on peut utiliser les cartes à perforation marginale binaire de grand format, par exemple 208 x 298 mm, ou de proches dimensions.

Dans pareil cas en outre de la clé droite (une indice déterminée corresponde à chaque perforation) on peut également employer des système différents de clés combinées (6). En cette occurrence le volume des informations à introduir au système peut pratiquement être infini. Cependant, il ne faut pas oublier que plus la clé devient-elle compliquée, plus augmente la possibilité des fautes lors de coupage d'encoches et de délissage de cartes.

Dans certains cas, des massifs parallèles peuvent être formés, en vue de répondre à des besoins particuliers. Par exemple, les systèmes spécials d'indexation permettant faire une classification des supports ou des pigments, munis des caractéristiques supplémentaires qui tiennent compte d'intérêts personnels peuvent être installes.

L'ouvrage de J.Plesters peut servir d'exemple d'une telle classification concernant les vernis à peindre. On pourrait recommander aussi d'autres variantes, élaborées en vue de demandes personnelles des savants et de possibilités différentes des systèmes d'information.

4.2. Introduction des informations dans le système

La codification se fait de la même façon que dans le cas de premier massif (voir 3.2.).

Il est recommandé:

1) de donner aux auteurs des originaux ainsi qu'aux titres des oeuvres anonymes les mêmes numéros qu'ils ont dans le premier massif;

2) d'inscrire les noms des pays (lieux de création des originaux) sur la carte-clé au mesure de traitement des sources, mais les placer dans le même ordre que dans le premier massif.

4.3. Conservation et réception (livraison) des informations

On réalise cette opérations de la même façon que nous avons indiqué dans les paragraphes 3.3 et 3.4.

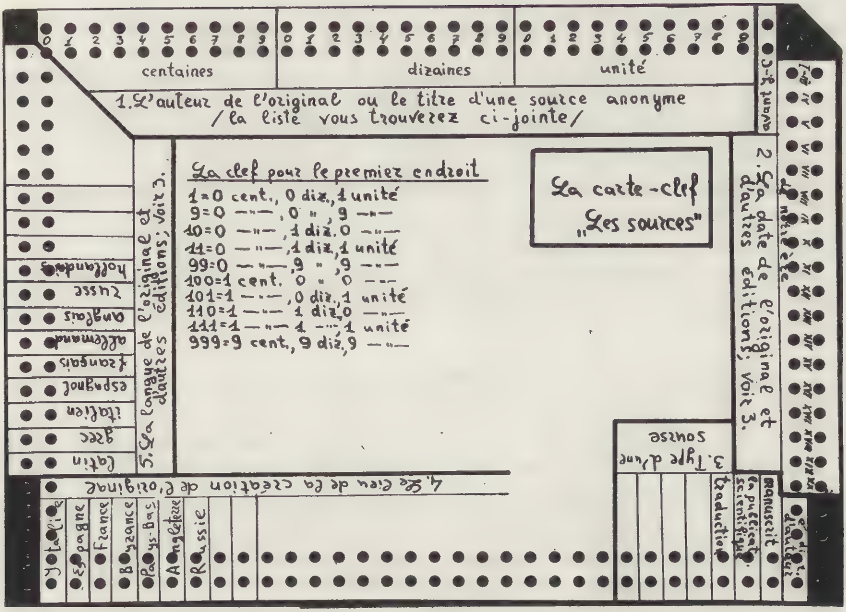
centaines
dizaines
unité
1. L'auteur de l'original ou le titre d'une source anonyme
/la liste vous trouverez ci-jointe/
La clef pour le premier endroit
1=0 cent., 0 diz., 1 unité
9=0 —"— , 0 " , 9 —"—
10=0 —"— , 1 diz. 0 —"—
11=0 —"— , 1 diz., 1 unité
99=0 —"— , 9 " , 9 —"—
100=1 cent. 0 " 0 —"—
101=1 —"— , 0 diz., 1 unité
110=1 —"— 1 diz., 0 —"—
111=1 —"— 1 —"— 1 unité
999=9 cent., 9 diz., 9 —"—
La carte-clef
„Les sources"
2. La date de l'original et d'autres éditions; voir 3.
5. La langue de l'original et d'autres éditions; voir 3.
hollandais
russe
anglais
allemand
français
espagnol
italien
grec
latin
4. Le lieu de la création de l'original
Italie
Espagne
France
Byzance
Pays-Bas
Angleterre
Russie
3. Type d'une source
traduction
la publicat. scientifique
manuscrit
d'autres éditions

fig. 1

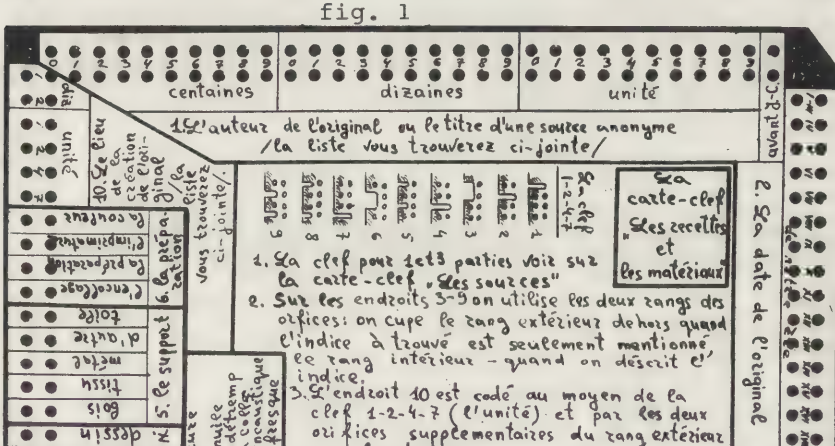
centaines
dizaines
unité
1. L'auteur de l'original ou le titre d'une source anonyme
/la liste vous trouverez ci-jointe/
La carte-clef
„Les recettes
et
les matériaux"
2. La date de l'original
10. Le lieu de la création de l'original /la liste vous trouverez ci-jointe/
unité
diz.
6. La préparation
la couleur
l'imprimature
la préparation
l'encollage
5. Le support
toile
d'autre
métal
tissu
bois
X. dessin
4. La sorte et la technique de la peinture:
1. murale
2. miniature
3. à l'huile
4. à la détrempe
5. à la colle
6. l'encaustique
7. la fresque
La clef 1-2-4-7
1. La clef pour 1 et 3 parties voir sur la carte-clef „Les sources"
2. Sur les endroits 3-9 on utilise les deux rangs des orifices: on cupe le rang extérieur dehors quand l'indice à trouvé est seulement mentionné, le rang intérieur - quand on décrit l'indice.
3. L'endroit 10 est codé au moyen de la clef 1-2-4-7 (l'unité) et par les deux orifices supplémentaires du rang extérieur pour les dizaines.
3. Le matériel du support, de la préparation, du dessin, de la couche picturale, et protectrice /la liste vous trouverez ci-jointe/
8. couche picturale
9. la couche protectrice

fig. 2

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CLASSIFICATION OF FEATURES OF EASEL PAINTING ITEMS FOR USE IN AN INFORMATION SYSTEM WITH SUPERPOSITION CARDS

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On the 2nd plenary session of ICOM Committee for Conservation (Amsterdam 1969) a working group for "Documentation" section was created. This working group presented to the IIIrd plenary session of the Committee (Madrid, 1972) reports containing suggestions on organisation of information service system. In particularily a report on manual information system with superposition puched cards that received aproval of the Committe[1].

The recomended system is created on the basis of indexation of features on superposition (visual, optical) punched cards. Such a system is simple in handling, economically proves its value, and is suitable for both large and small art museums. Being put into practice in national scales it will make it possible to unite museum information on an international scale.

At the recommended system each individual punched card records identical features (characteristics) that are inherent in all works of art to be found in a museum collection, in the other words all objects having this feature are recorded on the same punched card.

Thus the number of punched cards united in a file exactly corresponds to the number of features to be recorded, stored and easily achieved. The number of features (characteristics) to be recorded in the system,

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1) See Yu.I.Grenberg. Some problems of elaboration of museum documentation for information service. Madrid. October. 2-8, 1972, Published by ICOM Committee for Conservation.

and hence that of puched-cards can be continuously enlarged and does not involve any condition.

A certain feature of work of art is recorded openly on according supperposition punched card viz author, subject, date, kind of support, gesso, conservational treatment and so on. Then ordinal numbers of all works of art that have given feature are punched on the corresponding superposition punched card.

Let us assume there is a male gala portrait of the 3rd quarter of the XVIII century that was painted on a beech panel, with gesso, in oil paint and that marked in museum inventory under number 518. Let us choose fro the pack all punched cards under titles: male portrait, the IIIrd quarter of XVIII century, beech panel, gesso, oil.

Let us punch the hole number 518 on each of these six cards that would mean that the picture listed under number 518 has all these features. Thus punching of hol number 518 on a punched card labeled "beech panel" mean that a portrait listed under number 518 is painted on a beech panel. Each picture would be treated in the same way.

To find out a portrait that has listed features you must take punched cards of male portrait, the 3rd quarter of the XVI century, beech panel, gesso, and oil, then place them on the top of each other. All these card would have several holes (their number depends on a number of paintings that have given features). But if in the museum collection there is only one picture that ha all features in which we are interested, then having held up this stock of card to the light (therefor it other name optical or visual superposition punched card) one sees through the cards at the number 518 only. It may be possible that in the museum collection there is one analogious picture more. It would result in one through hole more.

If it is necessary for a user to form an oppinion about the evolution of male portrait in Europe needs only to take the card with correspondent titel. Numbers of all items in question regardless to their authors and dates of completion would be coded on it by means of holes. If we wish to limit their number with that of completion time, school, painting technique and other features it is enough to place the first card on top of a card (cards) with other features and have a needed answer.

Such punched cards have different information scope that as a rule does not exceed ten thousands of numbers. However the scope of works of art covered by such a system can be easily enlarged. For obtaining this aim it is enough only to make a parallel card stock. To this aim one labels the top edge of punched card with index +10000. Then adding to any found on a card number 10000 we would have the item in question.

An information system base on feature-index needs that each item included into the system has its own ordinal number. At the same time in museums not seldom inventory numeration have additional indeces of departments, dates of acquisition etc. Because all this is unfit to the given system all museum objects must get either a new numeration or excisting currently in parallel index must include museum inventory numbers corresponding to that being punched on cards. The latter way would be probably the only acceptable one especially for old museums. He deas no additional labeling of works of art and make it be possible to insert a new information system. Since one obtained answer on subject in question in a form of a number it is necessary to use subject-card file to identify these numbers with works of art.

The most crusial stage of creation of an information system is choice of features for which separate punched cards to be used[1].

Of course every art museum, laboratory, restorational studio can have punched cards adjusted for its particular aims. However one must remember that a system called upon to supply information to a wide net of institutions and individual experts must first of all accumulate information according to a standard list. It is necessary for it to classify features on level of state standard and in its own turn to enable us creat a common center of such documentation storage. In this united center can use already not manual but one or other way of mechanical handling and distribution of information.

---

1) Choosing some information it should be thoroughly analysed for evaluation of its content. Each work of art must be put into terms of certain number of objective features which must be considered defined qualitative characteristics of items (materials) and which may be determined as having only one meaning.

Evedently it is the useful to divide all features of works of art that to be recorded into three parts accor ing their meaning: a) art-historical, b) restorational, c) technological.

Each of this part is divided into sections in which features punched cards are in alphabetical order.

Following system of feature classification of easel painting obests is suggested.

A. Art-historical data [1]

Titles of rubrics and punched cards	Notes on rubric choosing and recording of punched-cards
National school [2]	On the punched-cards that are included in this section the numbers of all objects of a given collection, conserning to each national school are punched through. It is done irrespectively of level of their attribution (the works of unknown masters, of uncertain dating, of pracise attribution, questionable, fakes and so on).
England	
France	
Italy	
Russia	
.....	
?	
.....	Puched cards are done for those national schools, pictures of which are represented in given collection These punched card are arranged alphabetically.
	In the case when some works can not be attributed to a certain national school, their numbers are punched on a separate card of this section marked with sign "?".

1) The aim of this section is to answer most complitely where, when and by whom the questioned work are done and to what ganre it is conserned.

2) In frames titles of rubrics and subrubrics are done, without of frames such of punched cards.

All classificational features of given group are recorded in an open text. For instance. Rubens Piter Paul, 1577-1640, Flandria, author. The underlined is the titel of a punched-card (say in other words it is a feature that is fixed on it), „Flandria" is the nearest subrubric. „Author" is a rubric).

Local schools

Italy

Venician

Sienise

.....

The rubric is included according with condictional for art history dividing. Local interests of given collection also can be taken into consideration.

See note to heading "National school".

Author

France

Clue

Poussin

Watteau

Watteau *

.....

Punched cards with author's name are placed according national schools. Both (authors and schools) are arranged alphabetically.

In these punched cards family and names of an author is inscribed in full form in language that is approved with national standard and in native language of the author, dates of his life are given.

Numbers of works whosk attribution is considered as conventional are punched throu panched card.

All objects in some way or other related with the name of an author are fixed in punched card next to main one and marked with sigh "*". The fixed here numbers should be interpretted by means of punched cards of rubric "Related with an author". If there is no attributed work of this author in this collection the file can have only punched card with sign "*".

Related with an author

Master's circle

Shop work

Schobe of a master

Ascribed to

Doubtful

.....

The punched cards of this rubric fixes (records) numbers of all works of given collection related in some way with any master.

The punched card "Ascribed to" fixes numbers of all works whose belonging to national and local school, a master, his shopwork, circle and so on, ascribed under condition or called in question (or disputed).

The punched card "Doubtful" fixed numbers of all work whose attribution is in the least degree probable.

Copies and replicas

Fakes

In these two rubricas there can be punched cards of different degrees of differenciation: old replicas (fakes), morderen replicas (fakes), training copies, in exact replicas and so on.

Date

I century
.....
XX century
1/2
2/2
1/4
.....
4/4
10
.....
90
1
.....
9

Numbers of works dated within one century are punched throu a correspondent punched card.

Numbers of works dated within a part of century are punched throu a correspondent punched card and throu a punched card of correspondent century.

Additional differenciation based on decades can be inserted.

Numbers of exactly dated works are punched on punched cards of centuries, decades and each year.

Aproximately

Circa

On the punched cards "Aproximately" and "Circa" numbers of work that are dated conditionally. This uncertain date are in the same time punched throu main punched-card of rubric "Date".

Genre

Genre painting
Still alive
Landscape
Portrait
Tematical picture

All pictures of a given genre irrespectivly of their author and of school are fixed on correspondent punched card. Dividing into genre (subjects) can be made on any level. Punched cards are arranged in an alphabetical order.

Portrait

Group portrait
Child portrait
Female -"-
Male -"-
Gale -"-
Double -"-

Every division of rubric "Genre" can be subdivide into smaller parts. Punched cards within each group are arranged alphabetically.

B. Restorational data [1]

Restoration

All objects of museum collection are

---

1) The aim of this section of file is to answer questions related with changing and alterations of original appearence of picture or its structure as a result of restorational or any other outside interference.

Restorated
Restorated?
Not restorated
Alteration of size
Lining
Transfer
Has overpainting
Removal of old varnish
Cleaning
.....

punched on these punched cards. The cards are filled only with qualified conclusion of an expert.

Any operations having any effects on appearance and structure of work of art may be included in this rubric.

Lining

Relined
with wood
with metal
with canvas
.....

Any division of the rubric "Restoration" may be subdivied into more particular details.

Transfer onto a new support

Transfered from wood:
onto canvas
onto wood
onto metal
.....

Alteration of size

Lessening of original size

Enlarging of original size
.....

Or any other alteration for example oval instead of original rectangular form and so on.

C. Technological data [1)]

Examination

Macrophotography
X-ray
Visual luminiscence
IR photography

On punched-cards of this rubric numbers of pictures that were be examined by one or another method are punched.

Results of examination as photorecords are stored in technical dossier that has the same ordinal number as the works under investigation.

---

1) The aim of this section is to answer with possible comprehensivness how and of what materials each work of museum collection was done and of its technological and specific features.

75/7/4-8

Cross-section

.....

Support

Paper
Wood
Cardboard
Bone
Metal
Textile
.....

All information of this division of card-file is fixed only as a result of examination, the support being an exception and its punched cards being filled by results of visual inspection of object.

Wood support

Wood-support-examination

This punched-card fixes numbers of works, support of which are examined. Kind of undestructive examination is determined by superposition punched-card of rubric "Examination" and specifies according to the technical dossier of a work of art.

Beech-wood
Oak-wood
Lime-wood
Walnut
Pine-wood
Different kinds of wood in one panel
.....

Identification of wood kind of support can be done to level of genus and species that depends on a level of used examination, for example besides feature card "Pine" that of "Meditterenian pine (Pinea)" may be included.

In all cases besides denomination in language of compiler Latin conventional denomination.

Construction of panel

/Number of panels, ways of treatment, joints, their material, frames or any other features that can be classified/

It is done on the grounds of visual observation (besides that of materials) and analysis data.

Textile support

Textile- an examination
Flax
Hemp
Cotton
Jute
.....

See note to feature-card "Wood-support - examination".

Type of weaving

In this rubric any features concerning weaving specific (canvas density, thread spin, thread colour, pattern, presence of selvage and so on) may be fixed in a correspondent feature card.

In an analogous way one should approuch also to fixation of features of paintings done on paper support, metal or on any other material.

Stretcher

/Type, construction, material or any other features that can be classified/

It is done on the ground of visual observation (besides that of materials) and analysis data.

Nails

Metal
Wood
.....

On the ground of visual observation.

Nails-material

Oak-wood
Iron
Copper
.....

On the ground of analysis data.

Ground

Ground-examination
White-ground
Coloured-ground
Toned-ground
.....

All works grounds of which are examened are fixed on this punched-card.

Toned-ground is different from coloured one by intencity of colouration.

Ground-material

Gesso
Chalk-grue ground
White lead ground
.....

Under appropriate conditions feature-cards for data of microscopical, emissional spectral, X-rays diffraction and other kinds analyses. For details see note to rubric "Pigments".

Method of ground material identification is determined by means of punched-cards of special index.

One layered-ground
Multilayered-ground

Ground that has more than one layer.

Pigments in ground Ochre Charcoal Umber	See note to feature-card "Gesso".
Ground (single-layered) - media Glue Oil Wax Emulsion	See note to feature card "Gesso" If conditions of this institutio enable more detailed identification to be done subdivisions (glue-anima vegetable; kind of gum; kind of dry ing oil).
Multilayered ground media	Rubric is to be inserted under condition of real identification of vehicle for each layer. Feature car are filled according identification possibility.
Priming White priming Coloured priming	
Coloured priming Blue Green Gray Red	
Priming-pigments Cinnabar Ochre	See note to feature-card "Gesso"
Drawing Drawing-examination Scratching Charcoal Pencil Ink Chalk	See note to feature-card "Wood-support - examination".
Paint layer Multilayered painting Painting à la prima	

Pigments	
Pigments-examination White paint Yellow paint Green paint	See note to feature-card "Wood-support - examination". These punched cards fixed pictures of which areas of certain colours were examined. A technical dossier must include coordinates of samples precise to the level of millimeter. It is recommended to fix site of sampling onto coordinate axes X, Y assuming lower left-hand corner as 0, 0.
White pigments	
White lead White lead	Punched-cards of this group show the fact that white lead is found as pure paint or in composed paint of white colour. Index is to show method of pigment examination is microchemical, and is emission spectral analysis. In this case only the fact of white lead presence in a paint being fixed.
White lead basic lead carbonate $2PbCO_3 Pb(OH)_2$ /X-ray difr./	Further one group of feature-cards recommended by Mr Kühn for white lead is done as an example for more detailed pigment revealing.
White lead neutral lead carbonate $PbCO_3$ /X-ray difr. + IRS/	The pigment is identified by X-ray diffraction powder pattern by Debay-Scherer.
White lead, mixture $2PbCO_3 Pb(OH)_2 + PbCO_3$ /X-ray/	
White lead with traces of copper (silver traces much smaller than copper ones or below detection limit)	Analogous feature-cards may be introduced for other micro-elements or for other analytic methods used for their identification, analysis by means of neitron activation for instance.
White lead with traces of copper, and silver, silver traces is about equal quantities as copper ones	

75/7/4-12

White lead with traces of copper, silver, and tin.

Wtine lead without any microelements

Impurities are below detection limit. Punched-cards for such features as part-cle size or grain form may be including to enable one have additional informatio for chonological and topographical clas-sification of pigments.

+ White lead

In this rubric punched-cards for any pigment may be included. The + sign me-ans that this pigment is in a paint of different with it colour. For instance white lead in blue or red paint. For mor precise difinition this feature-card is combined with feature-cards for colours of paint: "yellow paint", "blue paint" and so on.

Zink white

Detailed identification depends on an lytical possibilities of the institution that carries out investigation and amoun of data that are necessary and sufficien for its perfect characteristics relative ly lo time and place of its manufacturin and using.

Red pigments

Cinnabar

This rubric is introduced if there is more detailed identified pigment, for in stance, "mineral cinnabar", "vermilion".

Read lead

If not feature-card with name of pig-ment only to be introduced.

Paint layer-Media

Media-examination

See note to feature-card "Wood-suppor examination".

Wax
Drying oils
Egg tempera
.....

It means media for single-layered pa-intings and pictures painted in one me-dia only.

Drying oil

Linseed oil
Nut oil

This rubric may be introduced for any media if it could be identified with mor details.

Presence in main media of other ingre-dients is marked on a card by sign +, fo

instance, in rubric "Media" feature-card "Drying oil + resin" or "Linseed oil + resin" may be introduced.

If this resin is identified a corresponding feature card may be introduced, for instance "Mastix in drying oil" and so on.

Feature-cards showing character of media of separate paint layers may be introduced. For instance "Siccative drying oil in underpainting", "Drying oil + natural resins in upper layer of painting", "Natural resin in glaze" and so on.

Protective layer

Protective layer-examination — See note to feature-card "Wood-support - examination".

Protective layer is absent — Method of identification is fixed.
Protective layer of varnish
Protective layer of wax
.....

Protective layer-material — All rubrics and individual feature-cards of this section to be introduced only under the condition that materials can be identified. The same condition determines level of detailing.

Bee wax
Oil warnish
Rosin varnish
.....

Oil

Linseed oil
Flux oil
.....

Resins

Dammar
Mastix
Amber
Sandarac
.....

Complex compositions